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Project: R8333

Sustainable Use of Groundwater in the Semi-arid Ribbon Valleys of Northeast Brazil

Inception Report

July 2004

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Issue and Revision Record

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"It is easier to observe the movement of the stars

than to understand the movement of the waters"

Galileu Galilei

Executive Summary

BACKGROUND

The Brazilian Northeast is a semi-arid area beset by severe droughts, unequal land distribution and rural poverty, which all help contribute towards an overall mass migration away from the region. The study region for this Project is based in the state of Pernambuco, which has a climate ranging from tropical along the coast to semi-arid (Sertão) in the interior. Long periods of drought have limited the extent of agricultural activity, with rural productivity in the region in the past fifty years centring on logging of local forests for charcoal production. This activity has had severe detrimental effects on the local micro-climate resulting in desertification, ensuing increased rainwater run-off and decreased recharge of the local alluvial aquifers.

Evidence of Extreme Contrasts in Climate (Campo Alegre)

THE PROJECT

The Project has three main aims:

1. Develop and disseminate clearly understandable, culturally appropriate guidelines for sustainable groundwater resource management, primarily targeted at subsistence farmers and farmer groups. It has become clear that the guidelines should not only be targeted at farmers, but that whole communities within the study areas need to be considered.

2. Facilitate and increase understanding amongst the rural population on the potential benefits from groundwater resource management and the implications of the overuse of the resource, in the context of seasonal and long-term variability in hydrological/climatic conditions.

3. Empower community representatives (farmers, farmer representatives and other local groundwater users) in the active monitoring and collective management of the groundwater resource.

THE PROJECT TEAM

The Project team comprises junior and senior specialists from Brazil and the UK. The Brazilian collaborators include FUNDAJ, the UFPE and UFRPE, while the UK collaborators include Mott MacDonald and Birmingham University. It is anticipated that further collaboration may be achieved through inclusion of a PhD student from the University of East Anglia.

The Project team comprises specialists form distinctly different professional and cultural backgrounds. Both professional and cultural differences have influenced the approach to the Project. For the technical specialists the challenge is to move away from the traditional technical approach to projects. On the other hand the social development specialists have generally only limited appreciation for pure technical issues. It has become quite clear during the inception stage that close collaboration between the technical and social development sub-teams is a pre-requisite for a successful outcome of the Project. Team building is therefore a very important component of the Project and this requires constant reminder of the team members of firstly the goal, purpose and outputs of the Project and, secondly, that working in isolation will not contribute to Project success and that communication is essential.

THE LOCAL COMMUNITIES

The social structures within the three study areas selected for the Project (located within the Pesqueira municipality of the Pernambuco State) are heterogeneous. Some people are financially secure but the majority are poor, with the landless groups being the poorest. Due to limited work opportunities, many of these families rely on support from government social programmes. The elderly play a very important role and have a high standing at the community level and contribute financially to family livelihoods.

Subsistence agriculture is largely rainfed, while irrigation plays a role of varying importance in the study areas, largely depending on groundwater resource availability. The success of agricultural production is largely dependent on climatic conditions and availability of groundwater for irrigation. Uncertainties in climate, combined with poor understanding of groundwater resources availability and sustainable use, lead to both reluctance to invest and loss of income due to crop failure.

Micro Sprinklers in Rosário

Queuing for Water

Lack of water for domestic use is evident during drought periods and creates significant inconvenience and suffering of the local communities. During drought periods, traditional sources become unavailable due to either shortage of water or poor water quality and communities become dependent on water supply by water truck.

Uncontrolled Commercial Exploitation of Groundwater in Mimoso

Droughts also severely impact on community relationships due to inadequate institutional arrangements regarding the exploitation of groundwater. Groundwater is being exploited by entrepreneurs for water supply to the more affluent in urban centres, possibly at the

expense of water users within the communities. Availability of scarce groundwater resources also becomes constrained by well and land ownership.

Lace Making in Campo Alegre

Lace making provides an important source of income, particularly during drought periods when unemployment is high and there is no income from agriculture. During drought periods, migration is still the main option to overcome difficulties. Men usually migrate to the large urban centres and leave their families in their homes. Most migrants return after climatic conditions have improved.

KEY PROJECT ISSUES

Project outputs have been identified as follows:

(a) Inception: Livelihood, Water Use and Environmental Surveys

(b) Package 1: Guidelines for Sustainable Water Resources Management

(c) Package 2: Framework for Participation and Education

(d) Package 3: Operational Strategy for Integrated Communications

(e) Package 4: Guidance on Monitoring and Intervention Strategies

Commencing from the basic aim of the Project which is:

- Capacity building of local communities in semi-arid areas to achieve sustainable use of groundwater resources for domestic and agricultural needs.

And, recognising that the Project seeks to achieve these purposes through:

- Developing community awareness of catchment hydrology and appropriate methods of water resources assessment.
- Developing community level awareness of short and long-term approaches to minimising the impact of drought that acknowledge the uncertainty in the climatic conditions in the region and include some assessment of risk (notably by the farming communities).
- Developing community understanding of water management and the role of community-based water management, recognising and supported within existing national and regional policy frameworks.
- Education in the areas of water harvesting, storage and water quality and related health issues.

Then the key issue for the Project is the choice of approach to creating the community framework that can be the recipient and repository for the anticipated developments in such a way as to ensure that the developments achieved in the next two years have a lasting rather than a transient impact.

ACTIVITIES TO DATE

The work that has been carried out to date has involved:

- The collation of data characterising the area, the national and regional regulatory frameworks.
- Engaging and building links with the local communities.
- Forging close ties between the teams working on the technical and social issues to create the best environment for undertaking the work.
- Collection of new data on the study areas in the form of well and livelihood surveys to inform the Project team about the specific conditions in each of the three areas.
- Identification of further technical data collection strategies that are required to gain full knowledge of the physical settings in each catchment, the groundwater resource conditions and the pressures on the resource in terms of use and abuse.
- An initial well inventory has been carried out and gaps in the hydrological data have been identified (notably for Campo Alegre). Proposals to fill these gaps have been made and are being implemented.
- A preliminary assessment of strategies for dissemination of methods of groundwater management methods has been made. Tests of these strategies will be carried out in the regions in the coming year.

Survey Interview

Workshop in Campo Alegre

- Workshops have been undertaken to engage the local community and to begin to demonstrate the relationship between community control of groundwater and drought mitigation.
- Irrigation demonstration trials have been initiated and are in progress in the Mutuca study area.
- Consultation meetings have been held with stakeholder organisations.

Demonstration of Irrigation Trial during Workshop

INITIAL FINDINGS

The major findings that will influence the Project delivery include:

- The three study areas are diverse, both in terms of the water resources and social settings.
- The exploitation of groundwater resources of the area could be termed haphazard, with numerous shallow wells being sunk in different properties in an attempt to maximise individual gain.
- High levels of interest in the Project and in participation in the Project have been expressed by both local authorities and the local population.
- The challenge of full co-ordination and collaboration between the Project technical and social development teams is recognised and is a key factor for the successful outcome of the Project.
- There are several initial approaches to establishing water resources management within the communities in the three study areas that will need to be followed in the first instance. These should provide a framework for future development. They include strategies for establishing a user centred monitoring network arising out of the farmer associations; creating farmer level understanding of water optimisation in irrigated fields through demonstration trials; enhancing rainwater harvesting opportunities for rainfed agriculture and domestic water supply.
- There is a lack of a clear community basis for water management, other than the farmers associations (which are not fully functional) and a lack of government regulatory controls at the local level to support the empowerment of the local population.
- There is a need to engage both men and women in the water debate and to provide a greater focus on domestic level water supplies and the improvement of strategies for managing these. The broader issues of water consumption for all uses has been highlighted as an important alteration to the emphasis of the Project, whilst recognising that the main thrust of the study is concerned with agricultural water exploitation.
- There are complex differences between the three study areas in terms of physiographic, underground and demographic conditions. This calls for a sensitive approach to knowledge transfer that avoids the ‘one size fits all’ concept, while permitting clear messages to be exchanged without creating apparent inconsistency in style and knowledge spanning the three study areas.

Dug Well used for Irrigation in Rosário

Dug Well used for Irrigation and Domestic Supply

- There are severe limitations to the exploitation of the groundwater systems and a lack of hydrological data that will allow for the characterisation of the study areas. Gathering new data using community based soils and groundwater investigations will provide a vehicle for infilling the missing information about the functioning of the resources and will provide a basis for an education programme that will allow the community to see in a holistic manner how the water environment is affected by drought, excess and human induced stresses.
- There are clear discrepancies between the high economic return for water as a commodity supplied to the local towns and as a resource for farm level activity where economic returns are relatively poor. This applies in particular to the exploitation of groundwater by private individuals during drought periods. Understanding how far national and local water policies can be developed to monitor conflicts and impose sanctions on the misappropriation of water will be important.
- The establishment of the Xukurú reservation, within which one of the major surface water reservoirs is located, has created a degree of antagonism and mistrust not only between the neighbouring communities and the Xukurú, but also with the municipal governing bodies.
- The existence of a culture of grant aid (through material supplies – notably for irrigation provided by government) undermines self development within the local community and breaks the link between effective water control and costs versus benefits within agricultural production. The zero cost attached to water and the appropriation of power at low to zero costs to pump water is providing an imbalance in the economy that will need to be rectified progressively if community based management is to be effective.
- The social patterns and economic controls governing the migration of workers during drought periods reinforces problems due to a shortage of water by encouraging a lack of manpower investment in better managing and maintaining the environment. Wasted effort through this route limits the rate of development of efficient water use in the longer term.

PROJECT PLANNING

The dissemination of themed messages is proposed for the implementation stage. The themes are closely related to the Project outputs defined in the Log Frame and are integrated into a whole that should lead to the sustainable management of groundwater resources. The delivery of the messages to the local communities will be carefully timed so that they are not overpowering and hence made ineffective. At all times, the approach will aim at the empowerment of the participants representing the local communities and should draw them into wanting what the Project has to offer.

The four message themes are:

1. Water storage and use for domestic purposes
2. Water for farming, including irrigation
3. Land management for improved water harvesting and retention
4. Institutional and organisational aspects of groundwater management

The messages within the four themes will be progressively introduced through workshops in the period from July 2004 to April 2005. The themes are to some extent interdependent and will not be considered in isolation and at the conclusion to the implementation period between July 2004 and April 2005 the four sets of messages will be drawn together as an integrated whole, that brings together the different issues and potential solutions, and that is understood to all.

List of Acronyms

AMAS	Associação Menonita de Ação Social	Mennonite Social Action
ASA	Articulação do Semi-Árido	Semi-Arid Articulation
AS-PTA	Associação Projeto Tecnologia Alternativa	Alternative Technology Association
CAATINGA	ONG Ambientalista (Ouricuri- PE)	Environmental NGO located in Ouricuri - Pernambuco
CARITAS	ONG Católica internacional	International Catholic NGO
CEDAPP	Centro de Apoio ao Pequeno Produtor (ONG de Pesqueira)	Support Centre for the Small Farmer (Pesqueira NGO)
CIDA	Agência Canadense de Desenvolvimento Internacional	Canadian International Development Agency
COMPESA		State Water Supply Company
CPR		Common Poor Resources
CPRH	Companhia Pernambucana de Meio Ambiente	Pernambuco Environmental Company
CPT	Comissão Pastoral da Terra	Pastoral Land Commission of the Catholic Church (Land Reform Movement)
DFID	Departamento de Desenvolvimento Internacional (do Reino Unido)	Department for International Development, UK
DIACONIA	ONG Evangélica	Evangelical NGO
EMBRAPA	Empresa Brasileira de Pesquisas Agropecuárias	Brazilian Agency for Agricultural Research (Federal)
FADURPE	Fundação Apolônio Salles (UFRPE)	Foundation within UFRPE (research services)
FETAPE	Federação dos Trabalhadores da Agricultura de Pernambuco	Federation of Agricultural Workers in Pernambuco
FIDA	Fundo Internacional para o Desenvolvimento Agrario (das N Unidas)	IFAD - International Fund for Agricultural Development
FUNAI	Fundação Nacional do Indio	National Indian Foundation
FUNASA	Fundação Nacional de Saúde	National Health Foundation
FUNDAJ	Fundação Joaquim Nabuco	Joaquim Nabuco Foundation
FUNTEPE	Fundo de Terras do Estado de Pernambuco	Land Fund of the State of Pernambuco (State Government Land Reform Agency)
IBAMA	Instituto Brasileiro do Meio Ambiente	Brazilian Environmental Intitute
IBGE	Instituto Brasileiro de Geografia e Estatística	Brazilian Institute of Geography and Statistics
INCRA	Instituto Nacional de Colonização e Reforma Agrária	National Institute of Colinisation and Agrarian Reform
INPE	Instituto Nacional de Pesquisas Espaciais	National Institute of Spatial Research
IPA	Instituto de Pesquisas Agropecuárias (Estadual)	Agricultural Research Institute (Pernambuco)
MMTR-NE	Movimento de Mulheres Trabalhadoras Rurais do Nordeste	Northeastern Rural Workers Movement

MST	Movimento dos Sem Terra	Landless Movement
OXFAM (UKI)	ONG Britânica (Escritôrio nacional em Recife)	UK NGO (National office in Recife)
P1 MC	Programa um milhão de cisternas	A Million Cisterns Programme
PFL	Partido da Frente Liberal (Governo Municipal de Pesqueira)	Liberal Front Party (Pesqueira Municipal Government)
PROASNE	Proyeto das Águas Subterráneas do Nordeste	Underground Water Project for NE Brazil
Projeto Dom Helder Câmera	Projeto de Reforma Agraria e Desenvolvimento Rural - financiado pelo FIDA	Land Reform and Rural Development Project funded by IFAD and The Ministry of the Environment
Projeto Renascer	Projeto de Reforma Agrária do governo do Estado e Banco Mundial	Land Reform Project (State Government and the World Bank)
PT	Partido dos Trabalhadores (Governo Federal)	Workers Party (Federal Government)
SECTMA	Secretaria de Ciência, Tecnologia e Meio Ambiente	Secretary of Science, Technology and Environment (State Government)
STR	Sindicato dos Trabalhadores Rurais	Rural Workers' Union
UFPE	Universidade Federal de Pernambuco	Federal University of Pernambuco
UFRPE	Universidade Federal Rural de Pernambuco	Rural Federal University of Pernambuco
WRMP		Water Resources Management Policy

Glossary of Portuguese terms

assentamento	Legally established rural settlement where each family is allocated an area of land.
assentado	A legally recognised settler in an assentamento.
parceleiro	A settler who, although not legally recognised, occupies land which he or she may have purchased.
morador	A resident – in this case of an *assentamento* with no land entitlement.

1 Introduction

This report describes activities, progress and initial findings of the first seven months of the Project, which started on 9 November 2003. Chapter 2 re-iterates the goal, purpose and outputs of the Project as outlined in the original proposal for the Project. Chapter 3 describes the initial activities and findings. It also addresses the significance of the Project team in relation to a successful outcome of the Project. Chapter 4 includes a summary of knowledge review. A detailed knowledge review is presented in a separate report. Chapter 5 describes the surveys and workshops undertaken during the inception stage and also includes a stakeholder analysis. Chapter 6 describes the Project dissemination strategies. Chapter 7 summarises the key findings and issues that have arisen during the inception stage. Chapter 8 describes in detail the Project planning for the Project implementation stage, particularly for the period from July 1004 to April 2005.

2 Goals, Purpose and Outputs of the Project

2.1 Introduction

The Log Frame, produced for the Project proposal, is reproduced in Appendix A. In the following sections the narrative summary of the Log Frame is given and issues that have arisen during the inception stage are highlighted.

2.2 Project Goal

The goal of the research project is to reduce poverty in water scarce, semi-arid areas through sustainable use of groundwater resources, leading to a reduction in resource degradation and security in safe water supply and food production for the rural poor.

2.3 Project Purpose

The purpose of the Project is to demonstrate methods that will build the capacity of local communities in semi-arid areas to achieve the sustainable use of groundwater resources for agricultural production and domestic needs. The demonstration is being carried out in three study areas in the Semi arid area of North-east Brazil: Mimosa/Rosário, Campo Alegre and Mutuca. Long-term sustainable use of the groundwater resource, through local management of the resource by the end-users, will lead to:

1. Improved social standing of the local community (empowerment and participation in the management process).

2. Reduced vulnerability and better livelihood outcomes through more secure water supply for domestic and agricultural purposes and food production (particularly during severe drought periods).

3. Reduction of harmful environmental impacts of over-exploitation of the groundwater resource (soil and water salinisation and stress on natural vegetation imposed by groundwater level decline).

The purpose is expressed in different yet quite appropriate words in the Project proposal as follows:

- **Develop** and **disseminate** clearly understandable, culturally appropriate guidelines for sustainable groundwater resource management, primarily targeted at subsistence farmers and farmer groups.
- **Enable** farmers to understand the potential benefits from groundwater resource management and the implications of overuse of the resource, in the context of seasonal and longer-term variability in hydrological/climatic conditions.
- **Empower** community representatives (farmers, farmer representatives and other local groundwater users) in the active monitoring and collective management of the groundwater resource in the context of water security for domestic and irrigation needs within their organisations.

2.4 Project Outputs

In order to achieve the Project purposes and to effectively assess the progress of the Project, Project outputs are identified and outlined as follows:

(i) Inception: Livelihood, Water Use and Environmental Surveys

This output relates to the development of a clear understanding of livelihood framework for small farmers in the study areas (men and women), and the role of water and irrigation water. The understanding is based on livelihood, water use and environmental surveys undertaken during the inception stage.

(ii) Package 1: Guidelines for Sustainable Water Resources Management

This package includes the development of guidelines for sustainable resource management for irrigation schemes at farmer level. The following activities are linked to package 1:

1. Review of current monitoring arrangements and the implementation of new monitoring systems and schedules

2. Assessment of groundwater resource availability in each study area and the determination of indicators of groundwater stress

3. Evaluation of the impacts of groundwater development and the sustainability of the resource under different operational conditions and the timing of intervention.

4. Dissemination of the findings arising from activities 1 to 3 through the communication channels created to address package 2 and the resources developed under activity 2.

(iii) Package 2: Framework for Participation and Education

The development of a framework for farmer participation and education includes the following activities:

1. Consultation with end users, target audience representatives and local community leaders and the establishment of ground rules for interaction between the Project team and the local community.

2. Performing socio-economic assessments to identify under-represented groups/genders concerned with the Project goal and to establish the basis for their integration into the communication dialogue.

3. Carrying out participatory livelihood analyses (including water use and water needs analysis) with small-scale farmers.

4. Establish workshops, seminars and participatory surveys using the knowledge gained from activities 1 and 2.

5. Recording, reporting and evaluation of the results of the workshops and seminars.

(iv) Package 3: Operational Strategy for Integrated Communications

An operational strategy for integrated communications between small-scale farmers, researchers, managers and extension workers is required. The following activities are related to this package:

1. Development of communication strategies aimed at producing effective multi-channel communication from the farm level up to national level encompassing farmers, water user communities, appropriate NGO's, public bodies, extension services and research organisations.

2. Implementation of the communication strategy to contribute to and present the outputs of the technical research findings.

3. Recording and reporting of the findings of this phase of the research.

(v) Package 4: Guidance on Monitoring and Intervention Strategies

Guidance on convenient and cost-effective data collection strategies, involving individual farmers and farmer groups for the assessment of irrigation performance, water conservation and salinity control is needed to fulfil the Project goal. The following activities are related to this package:

1. Assessment of the local capability to undertake resource monitoring and to interpret/disseminate and action the results

2. Development of guidelines and procedures for acquiring resource status data, processing the data and interpreting and distributing the results.

3. Development of resource stress indicators, presentation of the basis for these and their dependence on future conditions.

4. Distribution of the procedures and guidelines and the publication of the strategies.

3 Initial Activities and Findings

3.1 Introduction

The Project was initiated through a long standing link between Mott MacDonald and Birmingham University and between Birmingham University and the two main Universities in Recife: the Universidade Federal de Pernambuco and the Universidade Federal Rurale de Pernambuco. Groundwater resource management in water-short areas throughout the world has been addressed, largely in technical terms, by each organisation over the past decades. Over the years there has been a developing recognition that adequate and sustainable resource management in less developed and water-short areas is not just a technical issue. It is closely linked to the ways in which local communities are involved, on a daily basis, in balancing resource sustainability with resource utilisation. Over-exploitation of water resources has often resulted in unsustainable situations (both in terms of resource availability and the environment) that have resulted in a worsening of the poverty trap within which local communities can find themselves.

There are many reasons for the unsustainable development of groundwater resources, which are related to both direct and indirect influences:

- Sustainable groundwater exploitation has been evident for hundreds of years in arid regions, with over-exploitation avoided by the low yields of the available water extraction methods.
- However, since the large-scale implementation of new technologies to extract groundwater, in particular motorised pumps and deep tubewells, the balance between natural resource replenishment and extraction has been lost, resulting in the deterioration in resource availability and quality, and in environmental degradation.
- Over-exploitation of natural vegetation, through over-grazing and deforestation, has often changed the quantity and quality of natural water resources systems.
- Groundwater resource exploitation has often been initiated by government organisations to rapidly improve livelihood conditions for rural populations. The availability of new technology to the private sector has also led to rapid, albeit often temporary, gains.
- In many case, the unsustainable use of groundwater resources is triggered by a lack of knowledge and understanding of the behaviour of these systems and their responses to both natural climatic variations and man-made interventions.

From previous work it is apparent that sustainable exploitation of scarce groundwater resources can only be successful if the following key concepts are observed:

- *Decentralised Control* - That responsibility for resource management is delegated, in rural areas where state control is hardly feasible, to the rural communities directly affected by resource utilisation/exploitation.
- *Knowledge of the Resource System* – That the basis for sustainable resource management stems from a thorough understanding of the behaviour of the resource system under a variety of environmental conditions and anthropogenic interventions, and that this understanding needs to reside with the local communities.
- *Monitoring* – That the understanding of groundwater resource availability and behaviour can only be obtained through active monitoring of the influences exerted on the water environment. These include observations of climatic conditions, groundwater reserves and quality, water utilisation and land use.

- *Variations in Water Need* - That water is used for a variety of purposes and that the priorities for different uses may vary between and within communities and with resource availability. The first priority for water is potable use: thereby enhancing the health of the community. However, the use of groundwater for irrigation also has considerable benefits: resulting in enhanced income from the sale of produce and so improving livelihoods.
- *Ownership Issues* - That the ownership of and the responsibility for the groundwater resource needs to be clearly defined and be agreed upon by the members of the local communities.

Sustainable groundwater use in semi-arid areas should provide for sustainable and equitable livelihoods within rural communities. The conditions being studied in Northeast Brazil are representative of many parts of the world where scarce water resources and conflicting interests in its utilisation have contributed to a low quality of livelihood for many of the population. In drought periods, this has led to migration from these rural areas, which has further reduced the socio-economic well being of those who remain.

The Project is undertaken in the Pesqeuira Municipality of Pernambuco State in Northeast Brazil. The three study areas are located in the upper part of the catchments of three main rivers:

1. Mimoso/Rosário in the Ipanema River basin
2. Campo Alegre in the Ipojuca River basin
3. Mutuca in the Capibaribe River basin

The Mutuca area extends into the Belo Jardim municipality. The location of the three study areas is shown in Figure 3.1.

3.2 Key Issues

3.2.1 Introduction

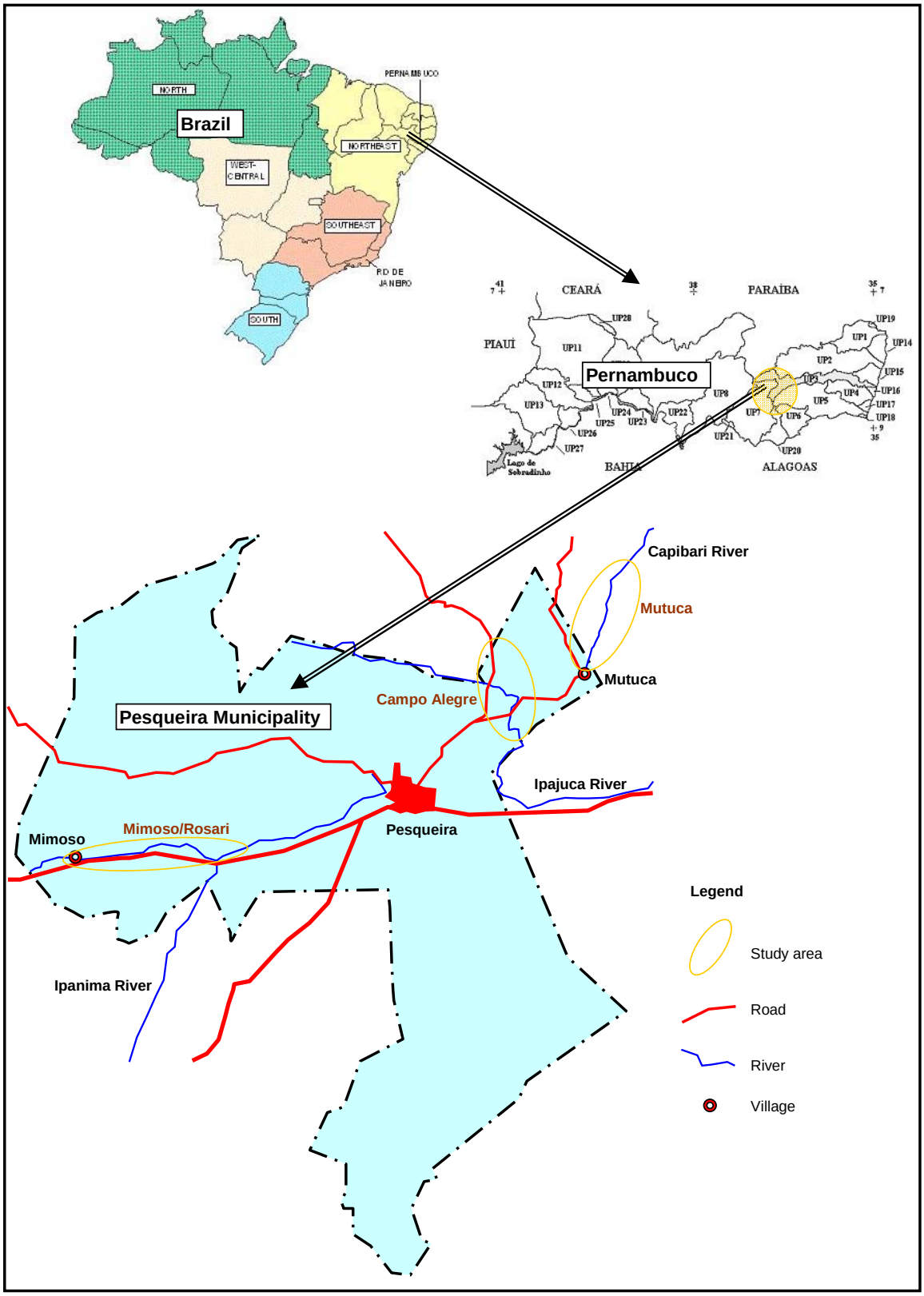
The goal, purpose and outputs of the Project have been summarised in Chapter 2. The issues and activities that the Project expects to address are described, in depth, in the following sections. Only those issues and related activities that are central to the successful outcome of the Project are considered. They go beyond those identified during the Project conception (as described in the Project proposal) and cover, in particular, the Project outputs and related activities as well as the demands on the Project team, to work and communicate effectively together during the Project implementation. The issues are described in the following sections in relation to the Project goal, the Project purpose and the four main Project packages.

3.2.2 Project Goal

Several issues in relation to the Project goal have been addressed during the inception stage and are reported on in more detail in the succeeding chapters. In summary they are:

- *The National Water Resources Policy 1997* (NWRP) issued by the Brazilian government is based on a number of basic principles, which will have a major bearing on the Project goal. The basic principles of the NWRP clearly emphasise the need for involvement of the whole community in the water resource management process. The full text of the NWRP is given in the Knowledge Review Report.

Figure 3.1: Location of Project Area



- *Use and ownership conflicts* related to use and ownership of the groundwater resource have become apparent during the inception stage. Resolving these conflicts is seen as a major challenge for the Project. Conflicts in resource use are time dependent and are less apparent during periods of water surplus. They become particularly relevant during extended drought periods when priority of use and equitable distribution amongst the communities become critical factors.
- *Decentralising the management of water resources* will require a major effort in order to provide the local communities with the necessary skills for resource management. Practical skills and resource and environmental management principles are all required to create a lasting capability. The use of educational facilities at all levels within the communities is seen as an important contribution to achieving the Project goal.

3.2.3 Project Purpose

Specific issues of particular relevance to achieving the Project purpose relate to the measurable indicators in the Log Frame. The issues as they relate to each of the measurable indicators are summarised here. The measurable indicators are headed in italics and the issues are described in the text that follows.

(f) Establishment of groups of participants in the three study areas.

Water Users Associations do not exist in any of the three areas and the Water User Associations identified at the State level are related to whole river basins which are too large to be relevant to the sub-basin catchments represented by the study areas. Local rural residents' associations are formally established in the two *assentamentos*, Campo Alegre and Rosário but the conclusion of the socio-economic surveys was that these are not fully representative or inclusive. Although it will be important to work with the associations during the period of the project, the team recognises the need to help foment other types of local organisation, for example of women, to ensure an optimum level of participation in project dialogue and learning.

(g) Agricultural production in study areas.

The issue here is concerned with a change in the relative weight to be given to irrigation production compared with rainfed agriculture and livestock agriculture. Irrigated agriculture is currently practised on a relatively small total area of the three study areas (mainly in Rosário), while rainfed agriculture and livestock rearing occupies a much larger area, notably in region of Campo Alegre. The question then arises about the best strategy for determining the potential improvements that can be made through the assessment of the agricultural production in study areas related to irrigation practices alone. It may be necessary to redefine the trials to cover a different spread of activities to achieve the Project goal, covering such issues as improved rainfed agriculture and associated improvements in groundwater recharge. This issue has only been partially resolved at present with a view that the irrigation demonstration trials should continue, with the associated monitoring in the catchments but that some hold back on Project resources is required to gain a greater insight into trials that could benefit the other areas of farming. However, the scope and scale of these trials has yet to be adequately defined.

(h) Salinity patterns over the study areas.

Groundwater salinity is an issue for irrigation and for other water uses. Groundwater salinity is a product of salt concentration due to evaporative processes and to rock transformation processes. The latter cannot be dealt with by the Project but its influence can be addressed through the assessment of options for desalination for domestic water use. The highest

salinities arise in the poorest aquifers where yields are low and more intensive exploitation of the water is not appropriate. Irrigation induced salinisation is an issue and will need to be dealt with as a time dependent phenomena that is partly affected by the spatial location of irrigated areas relative to the groundwater resource (recycling of water) and partly by the timing of recharge and flushing events (during floods). It will be necessary under the main project phase to gather more information about the impacts of location and to determine whether the costly reorganisation of irrigation patterns and 'ownership' of groundwater is justifiable.

(i) Water consumption in the study areas.

Water consumption in the context of the different water usages and the priority that may need to be placed on specific types of water use are of major relevance to the Project. This is especially true in periods of drought where there may need to be a control of irrigation to sustain groundwater for domestic/potable use. However, this could mean that incomes will be affected and the ability of the farmers to sustain their livelihood during these periods without the support of irrigation needs to be assessed. Introducing a self regulatory component to the water use practiced in the study areas during drought will provide an important test of the community level authority of any water user association and its membership's willingness to engage with community level regulation and will.

Note that drinking water is currently being supplied free of charge to residents by the municipal authorities using water trucks.

(j) Uptake and implementation of guidelines in farming communities across the wider region.

It has become clear that the guidelines should not only be targeted at farming communities, but that the whole community within the study areas need to be considered. As farming is not the sole income generating activity in the study areas, the guidelines for water resource management will need to extend beyond the farming communities and reach to all parts of the communities dependent on groundwater for their livelihood. Thus the guidelines developed will need to be inclusive of the whole community and will need to reflect the different contributions to water conservation and exploitation by the whole community.

(k) Greater water security for domestic purposes.

This is a gender issue. The surveys found that all women consulted in both the *assentamentos* are primarily interested in the provision of water for domestic and drinking purposes – as opposed to for irrigation and livestock. Moreover, this was confirmed in the dialogue conducted in both workshops with local rural people, which indicated that water security for domestic purposes is a priority for all.

(l) Interest in the results of the research by potential beneficiaries from areas outside of the study areas.

The problems faced by the communities in the study areas are common to major parts of the dry northeast region of Brazil and dissemination of the approach and findings needs to be given due attention. It seems likely that the best method for exporting the knowledge gained in the study areas will be to bring the results and the methods to the attention of NGOs and the relevant municipal, state and national organisations with an interest in promoting groundwater sustainability. Information will be produced in such a way as to be accessible and relevant to these organisations who will be invited to assist in the dissemination process throughout their networks both during and after the completion of the present Project.

3.2.4 Key Project Issue

Given the breadth of the issues perceived as important for the successful delivery of the Project, it is hard to establish one key issue that stands out above the others. However, if commencing from the basic aim of the Project which is:

- Capacity building of local communities in semi-arid areas to achieve sustainable use of groundwater resources for domestic and agricultural needs.

And, recognising that the Project seeks to achieve these purposes through:

- Developing community awareness of catchment hydrology and appropriate methods of water resources assessment.
- Developing community level awareness of short and long-term approaches to minimising the impact of drought that acknowledge the uncertainty in the climatic conditions in the region and include some assessment of risk (notably by the farming communities).
- Developing community understanding of water management and the role of community-based water management, recognising and supported within existing national and regional policy frameworks.
- Education in the areas of water harvesting, storage and water quality and related health issues.

One of the key challenges for the project is to ensure that the process of learning and awareness-raising regarding the benefits of groundwater management will not stop when the Project comes to an end. It is incumbent upon the Project team to make every effort to ensure that the processes that commence during the duration of the Project continue with the active support of other relevant agencies.

The Project team has spent some time deliberating this particular issue and has developed a strategy for staged, incremental dissemination of the messages from the Project This is to allow the full engagement of the communities and to allow them the time necessary to develop their own organisational structure to take advantage of the information and ideas that are being made available. It is also to enable Project team members to acquire a good understanding of local knowledge of water resource management and to develop a dynamic dialogue with local people.

3.2.5 Inception: Livelihood, Water Use and Environmental Surveys

Initial social, economic, environmental and water-use research has been one of the main activities of the inception phase. A summary of findings is given in Chapter 5 of this report. The work has included social mapping, assessment of attitudes to water and water use as well as to education, health, local government, community organisation, employment in agriculture and other income-generating activity, migration and land tenure. The methodology used throughout this work contemplated different gender roles and attitudes to these issues. Further detail about the methodologies employed for this research is given in Section 5.1.1. Surveys still have to be undertaken in the Mutuca area and in the Indian area with the Xukurú to complete the picture of the Project area.

The proposal emphasised the need to understand the livelihood framework for small farmers. It has become evident during the inception period that a high percentage of rural residents in the project area, in particular women, are either not engaged in farming activities or are so only occasionally to produce some subsistence crops. The NWRP clearly includes all water uses and also indicates the prioritisation of water use in relation to resource availability/scarcity.

The livelihood surveys undertaken during the inception stage have targeted a representative sample from two of the three communities included in the Project. The livelihood surveys include a strong emphasis on water use from a social development perspective. Separate surveys (as yet limited in extent) of water sources have been undertaken with a bias towards the technical issues related to water and the environment.

3.2.6 Package 1 – Development of Guidelines for Sustainable Resource Management

The elaboration of guidelines for more sustainable water resources management in rural communities in the study areas requires:

- Recognition of the importance of considering community water use in the context of different types of water use.
- Acknowledging environmental uncertainty as a major factor contributing to the sustainable use and management of water resources.
- Considering the ways local people manage uncertainty and their consequences for food security and household stability.
- Considering culture and history in shaping human-environment relationships in the region;
- Acquiring knowledge of the existing institutional arrangements for water use and management.
- Being general, but not too general, in order to take proper account of the social and physical heterogeneity present in the region.

These guidelines will be established on the basis of dialogue between local rural people, their advisers, team members and others as appropriate. It will be important to ensure that local people have a strong voice in this dialogue and in the drafting of guidelines to ensure that their knowledge, experience, needs and aspirations are fully reflected in the outcomes.

Two important items, not yet addressed by the KaR study, need to be incorporated in the guidelines. First, the use of seasonal climate forecasting as an opportunity for more pro-active planning at the municipal and community levels should be incorporated. Although the appropriate use of climate-related information in northeast Brazil constitutes a challenge in itself (Lemos *et al*., 2002), it should not be discarded as an opportunity to develop awareness and disseminate information. An appropriate methodology for the use of climate forecasts at the community level would be beneficial to the municipality and the rural communities alike.

Secondly, given the intrinsic variability of rainfall water coupled with lack of soil fertility in the region, techniques of water and soil conservation are essential. One of these, water harvesting, aims at increasing water availability for crops by guiding rainwater run-off from a catchment zone into the planting zone, which improves soil fertility and soil-water content. Run-off is made to infiltrate into the soil by the use of impounding structures. Types of different water harvesting systems may be found in Beets (1990). Guidelines for more sustainable water use and management should include water harvesting techniques as a major topic.

3.2.7 Package 2: Framework for Participation and Education

The Project will strive to ensure that lessons learnt throughout the Project's life span are disseminated and adopted by the rural communities as a whole. The approach taken in disseminating information

and involving the community with water management and environmental issues will need to be a holistic one determined by several factors:

- Throughout the rural northeast, literacy levels are often very low, particularly within older age groups. This is a key consideration for the design and implementation of education methods if participation of the community as a whole is to be encouraged.
- Current education curricula in the rural regions are based on urban models. Therefore, many valuable environmental, agricultural and water resources management skills are not imparted to the children of these regions.
- For the Project goals to succeed beyond the Project period, it is important that existing knowledge from the community is brought to the fore through participative community consultations and the identification and training of key community members, who will continue the education programmes. Continual consultative processes both within the wider community, and through the establishment of community advisory groups comprised of local teachers, health workers or other local persons as appropriate will help to create a framework for long term educational processes. This should ultimately lead to a sense of greater ownership of the Project and its aims by the communities.

Through an initial assessment of these issues throughout the inception phase, the Project team has identified certain issues to be addressed in Package 2 to ensure that the education and participatory framework is devised appropriately:

- Education programmes need to address the wider aspects of water use in each community to anticipate and mitigate conflict and increase co-operation between different water users. There is a need not only to focus on farmer groups, but also to consider domestic users.
- The different messages in relation to water use will need to be directed towards appropriate parts of the communities. For example, irrigation education programmes are only relevant to the farmers.
- The Technical team must receive systematic training in communication techniques, and social inclusion skills. Some of our collaborators (e.g. CEDAPP) may become involved with this training.
- Training of local trainers in water & environmental management. Local trainers will be selected from among rural teachers and health workers, among others, who are prepared to contribute to the Project.
- The involvement of local leaders, municipal government, church groups and NGOs will greatly aid the Project outcome.
- Education by example is important: outcomes from the workshops held in Rosário and Campo Alegre revealed that both community interest and involvement rose when the participants were confronted by particular examples and by interactions with people from different communities. Field trips will be organised to present examples of agricultural practice and water management, both within the study communities and in the wider northeast region. Visits are also envisaged to enable community members to view other projects (e.g. CEDAPP, CAATINGA, PROASNE, etc.) and for their representatives in turn to visit Pesqueira and the Project communities.

Application of an environmental education programme within the current education system is not immediately practicable. Consultation with the local Education Secretariat has revealed that the region's schools follow a national curriculum, which does not encompass rural environmental and agricultural issues. Moreover, there is no continuing adult education provision on these issues. Initially, the plan is to establish the materials for continuing education on water and environmental management applicable to the region and to identify forums where these materials can be introduced

into educational activities. Such forums could include church groups as well as the local schooling system.

3.2.8 Package 3: Operational Strategy for Integrated Communication

The communication strategy in the Log Frame relates to farmers, researchers, managers and extension workers. The inception stage has highlighted the need for involvement of representatives from the whole community, and has also indicated the need for involvement of local education institutions including institutions of local government as well as men, women and young people many of whom are not primarily farmers.

Thus, Package 3 should focus on the development of cross-scale organisational linkages for better use and management of water resources. Evidence from the 'common pool resources' literature, suggests that there is a need to design and promote management organisations at more than one level, with attention paid to the interactions across scales from the local level up (Berkes, 2002). Cross-scale interaction refers to the linking of organisations (i.e. formally and informally) both vertically (across levels of organisation) and horizontally (between regions). A well documented example of cross-scale linkage is co-management (Ostrom *et al*., 2002). In co-management, there is a sharing of both resources and responsibility between resource-dependent communities and government bodies. Scoones (1995:29) proposes that in order to manage common pool resources with high variability and associated uncertainties it is necessary for 'an effective hierarchy of institutional responsibility for resource management that stretches from the local to the national and sometimes beyond'. He argues that 'centralised bureaucracies tend to aggregate, standardize and prescribe, rather than differentiate, fine-tune and adapt.' Establishing the local management within a broader hierarchy or responsibility will be a significant task.

A pre-requisite for the emergence of cross-scale interactions is the strengthening of local-level institutions. If local associations in Rosário, Mutuca and Campo Alegre are fragile (and water user associations non-existent), there will be no solid foundations on which to build. Additionally, there must be an appropriate level of acceptance by municipal/state level authorities of the need for more participative approaches to water management and use. Although there isn't a need to formally define the separation of roles and responsibilities to embrace the participative approach there is a need for such roles and responsibilities to be at least tacitly understood by all parties.

The strategy for Package 3 can best focus on implementing 'common pool resources' strategy through co-management within the general framework of the Water Basin Committees and Water User Associations established by state decree in 2000. Informal interviews conducted in March 2004 revealed that the municipality of Pesqueira participates in two Water Basin Committees (for the Ipojuca and Ipanema rivers).

3.2.9 Package 4: Guidance on Monitoring and Intervention Strategies

Better monitoring of environmental signals and tighter response systems will be the key to the improvement of local livelihoods. Better monitoring practices should involve:

- Participation by water users from the three communities;
- Dissemination of environmental information within the communities;
- Identification of key environmental variables;
- Low-technology monitoring procedures and equipment; and,
- 'Qualitative' monitoring methods.

During the Inception phase, the 'malfunctioning' of monitoring practices was observed. The practice of monitoring water and salinity levels is either carried out by one or two members of each community or by external bodies. The information is not properly communicated (both in terms of dissemination and meaning) to the rest of the community. One of the barriers to the effective communication of monitoring data is its intrinsic quantitative character. Community members, who are not trained to deal with numerical data, need to process information by other means. The use of qualitative monitoring procedures (i.e. visual perception, touch, etc.) should also be incorporated. The translation of the raw data into other forms should also be encouraged.

While monitoring is essential to appreciate the conditions that prevail within each of the three study areas, it will only be through the adoption of agreed intervention strategies that progress towards community development and management of the resource can take place. In terms of intervention strategies, the literature on the management of common-pool resources suggests that the requirements for management include:

- the formulation of rules that take proper account of the ecological conditions;
- the creation of a framework to clearly define resource boundaries and user groups;
- the promotion of accountability mechanisms;
- the application of graduated sanctions for violators; and,
- the establishment and use of low-cost mechanisms for conflict resolution (Dietz *et al*., 2003:1910).

Well designed incentives may be a necessary but not a sufficient condition for cooperative management. A historically and politically grounded understanding of resources, rights and entitlements is a fundamental input to the design of the incentives and to the management of the resource (Moose, 1997; Leach *et al*., 1999).

3.3 Activities to Date

There is almost no published material available about Pesqueira history, geography, agriculture and livelihoods or other aspects of Pesqueira society. The social development team therefore began to construct a picture of this society using a range of social research methodologies including quantitative surveys, qualitative informal and formal interviewing sometimes in groups or families, sometimes of individuals, transect walks in the rural areas, identification of local key informants and other techniques.

The work that has been carried out to date to address the issues described in the previous sections has involved:

- The collation of data characterising the area, the national and regional regulatory frameworks.
- Engaging and building links with the local communities.
- Forging close ties between the teams working on the technical and social issues to create the best environment for undertaking the work.
- Collection of new data on the study areas in the form of well and livelihood surveys to inform the Project team about the specific conditions in each of the three areas.
- Identification of further technical data collection strategies that are required to gain full knowledge of the physical settings in each catchment, the groundwater resource conditions and the pressures on the resource in terms of use and abuse.

Technical information has been gathered on:

- The water master plans for the major basins encompassing the study areas.
- The physical and hydrometric data for the region
- The structure and characteristics of the three study areas in terms of water appropriation, use and control and related aspects of land use.
- Existing approaches to groundwater enhancement including better use of the resource for irrigation as well as improved control of the water through the implementation of underground dams.
- Salinity related issues for the most agriculturally developed study area.

An initial well inventory has been carried out and gaps in the hydrological data have been identified (notably for Campo Alegre). Proposals to fill these gaps have been made and are being implemented.

A preliminary assessment of strategies for dissemination of methods of groundwater management methods has been made. Tests of these strategies will be carried out in the regions in the coming year.

Two workshops have been undertaken to engage the local community and to begin to learn about community knowledge and needs as well as to demonstrate the relationship between community control of groundwater and drought mitigation.

Irrigation demonstration trials have been initiated and are in progress in the Mutuca study area.

In addition, consultation meetings have been held with the following organisations:

- Secretariat for Science, Technology and the Environment in Recife
- Antonio Jorge Siqueira, director of FUNDAJ
- FUNTEPE, Recife
- The Mayor of Pesqueira and others in the municipal government
- Secretariat of Agriculture, Environment, Food Supply and Water Resources at Pesqueira
- Secretariat of Education, Social Action and Health at Pesqueira
- Pesqueira catholic priest, nuns and lay workers, and associated NGO (CEDAPP)
- State water supply company (COMPESA)
- IBGE cartographers and demographers in Recife

3.4 Water Sources and Use

3.4.1 General

Water is used in the Pesqueira municipality for three main purposes:

- Domestic water supply
- Water supply for livestock
- Water for irrigation

Water for livestock and irrigation is restricted to the rural areas, while the supply mechanisms for domestic water supply differ between the urban area of Pesqueira town and the rural areas. The following sections will discuss the water sources and use for Pesqueira town and the rural

communities separately. Most information has been based on the livelihood and well surveys, and on discussions with the Secretariat for Agriculture, Environment, Food Supply and Water Resources in Pesqueira.

3.4.2 Water Supply to Pesqueira Town and Villages

During non-drought conditions, there is a piped water supply to Pesqueira town and to some of the smaller villages within the municipality such as Mimoso and Mutuca. Water supply is from several large reservoirs: Bituri reservoir near Belo Jardim (located between Pesqueira and Belo Jardim, with a capacity of 17.7 million m^3 and serving six major towns); Santana reservoir (located in the Xukurú reservation and with a full capacity of 2.2 million m^3); and, Ipaneminha reservoir (located to the west of Mimoso village and with a capacity of 4 million m^3). Water is also supplied from smaller reservoirs (Afetos and Pedra d'Água, located near Pesqueira town, with capacities of 1 and 0.16 million m^3 respectively). A new reservoir is planned (Rosas) near the Pesqueira Technical College. Mutuca village receives from Genipapo reservoir located in the Belo Jardim municipality.

In the early 1990's, water was released from Pão de Açucar reservoir (located in the Xukurú reservation north of Pesqueira , with a capacity of 34 million m^3) and fed into the pipeline running from Bituri reservoir to Pesqueira at the river crossing some 18 km downstream of the reservoir. This source of water is no longer available and no pipeline link exists between the reservoir and Pesqueira town. The reasons for not releasing water from the reservoir relate to the establishment of the Xukurú reservation in 1998 which extends downstream from the reservoir. This has resulted in the perception by the community in Campo Alegre that the Xukurú have ownership of the water resources within the reservation and are not willing to transfer water to communities downstream. It should be noted that insufficient water was stored in the reservoir during the drought period experienced during the past years, and that this partly explains that water was not released from the reservoir.

Water from the reservoirs is piped to a treatment works in Pesqueira, from which it is fed into the town piped distribution system. Responsibility for water supply lies largely with the COMPESA, the State-run water supply organisation. Water supply within Pesqueira town is intermittent in many of the neighbourhoods and leakage losses are high, indicative of a poorly maintained distribution system. Information on per capita consumption is not clear. COMPESA indicated a consumption of 266 000 m^3 for May 2004, which, for a town population of about 41 000 implies a very high per capita consumption of about 200 l/d.

During drought periods the volumes in the reservoirs reduce to the extent that water can no longer be transmitted by pipeline. Water trucks are used to transport water from the Santana reservoir to Pesqueira town. No payment for extraction of water from the reservoir is made to the Xukurú. Seven water trucks are operated by COMPESA and this increases to nine during extreme drought conditions, such as experienced during 2003. Water is transported to distribution points within the town where the water is collected by the town population. The water is provided free of charge. Treatment is in the form of chlorination at the abstraction point.

Part of the water supply, and this is particularly significant during drought periods, is in the private domain. The water is extracted from dug wells located in the western part of the Mimoso valley where groundwater is of good quality and where the groundwater reserves are significant. The wells are privately owned and well owners consider the groundwater underneath their land as their property. There is no control over the quantity of water that can be abstracted and, in effect, there is no need for a licence to abstract water, because shallow dug wells do, according to the National Water Policy, not require a licence. Water is sold to private individuals in Pesqueira town and to an army base located within the municipality. Water is also transported to towns in neighbouring municipalities. The private water supply is apparently very profitable to both the well operators and to some of the private individuals who buy the water. The latter sell the water on to local people.

3.4.3 Water Use in the Rural Areas

During non-drought periods, rural water supply is provided from the reservoirs in the region by water trucks (this water is primarily for drinking purpose as it is treated). Water is also available from local sources, mainly wells, small lakes or reservoirs and from rainwater harvesting cisterns (but this is largely for non-drinking purposes). There is no treatment of the locally derived water and health problems have been reported in the livelihood surveys due to lack of sanitation, which is especially dangerous during times of rain.

In drought periods, when most of the local sources are either exhausted or of poor quality, domestic water is primarily supplied from the Santana reservoir and delivered by water truck. Water is delivered to individual households and stored in their cisterns and other containers. The municipality owns and operates two trucks for water supply to schools, while two trucks are rented by the municipality.

Rainwater harvesting from roof areas is encouraged and subsidies are available from PRONAF for the construction of the cisterns. Harvesting is particularly encouraged in areas where access by water trucks is problematic and expensive. Informal information indicates that a 15 m^3 cistern can supply the potable water use of a family of five persons for one year. There is also unconfirmed information that the cisterns constructed under the subsidised programme are vulnerable to cracking during drought periods and that leakage occurs. Observations made during field trips, clearly indicate the lack of adequate construction and maintenance of the conveyance mechanism (mainly guttering) used to transmit the rainfall from the roof top to the cistern. Only a very few houses have guttering on their roofs.

During the period of the previous government (2001/2002), several social programmes were initiated to alleviate water supply problems in rural areas. Ten deep wells (for which a licence is required) were drilled in the bedrock formation in the study area. Only three were productive, and of these one produces a significant yield while the other two produce only low discharges. Desalination facilities were required to treat the brackish water abstracted from the wells. The initiative proved to be a failure, largely due to a lack of funding available to the municipality to operate and maintain the desalination plants. Concerns were also voiced by the local communities about the disposal of the waste products (salt) produced by the desalination process.

Dug wells are also used for domestic use and, generally, these are accessible to the community at no charge. The water is seldom used for drinking.

Livestock water supply is mainly from dug wells and a recent programme to install 30 new wells within the municipality (funded by PRONAF and managed by the Secretariat of Agriculture) has been completed. The quality of the water is generally poor, with relatively high salinity. However, this appears to be acceptable to the local farmers.

Water for irrigation is mainly derived from groundwater, although surface water is used when water is available from the rivers during the rainy season. The dug wells are located in or near the river bed and serve small plots of land in the three study areas, although irrigation is most extensive in the Mimoso/Rosário area.

At this stage, there is insufficient data defining quantities of water used for irrigation and livestock watering. Indicative quantities of groundwater abstracted for private supply to Pesqueira town have been derived from the well survey in this area (refer to Section ***), but these need to be verified.

3.5 Overview of Current Water Management Practices

Water management practices in the Pesqueira/Belo Jardim region illustrate the challenges identified by Common Pool Resource theory and demonstrate the influences of context and history in shaping water

use development in Northeast Brazil. The rural communities of Rosário, Mutuca and Campo Alegre struggle to maintain adequate supplies of water for multiple-purposes. At least three factors contribute to this condition:

- a lack of institutional arrangements for water management;
- a lack of awareness of the interactions and feedbacks between different activities;
- a lack of capital (social, physical and financial).

The inception phase for this Project has demonstrated that the institutional arrangements identified in the three communities are either non-existent or fragile. There is a lack of control governing what actions (or outcomes) are required, prohibited or permitted, and a lack of sanctions if the rules are not followed. As an example, water commercialisation by upstream smallholders in Mimoso/Rosário exploits not only the water of the small holders but also the water of downstream users. However, no recognition of this abuse of water rights and no sanctions have been established. Another example is the construction of multiple wells to enlarge single farms at Rosário, which also results in reduced throughflows to downstream water users. These types of water appropriation may ultimately lead to the failure of some parts of the community to sustain their livelihood. The problems in Campo Alegre are somewhat different as they are largely the result of problems of communal provision. Farmers in Campo Alegre are not able to cooperate to carry out the maintenance of critical infrastructure (i.e. dams) for water availability. Farmer associations (note that these also represent non farmers) do exist in both localities, but these are malfunctioning.

In Mutuca, Campo Alegre and Rosário, farmers and households are not able to frame the most basic operational rules to support day-to-day decisions about water use and management. Consequently, smallholders in these three localities have not been able to deal properly with operational dilemmas. The root cause for this may ultimately prove to be complex and, certainly, has not been adequately identified at this stage, but a clear lack of institutional development does pose challenges for the Project in developing operational guidance that can be successfully implemented.

Another challenge is the distribution of entitlements among the communities. Farmers in the three communities own property rights. This amount of land constrains income levels in the long-term. Moreover, land is frequently bought and sold in informal markets during drought episodes. This pattern of land redistribution has been more frequent in Rosário, where older landowners have sold the rights to their land and become landless peasants as a consequence of the droughts that occurred in the 1990s. Access to appropriate land sizes for subsistence and/or market crop cultivation, is identified in the literature as one of the main poverty drivers in Northeast Brazil (Ribot *et al*., 1996).

Groundwater can be assumed to ‘belong’ to the land beneath which it is located. This appears to be the case in the study areas. Farmers assume that they have rights to extract any water available beneath their land without regard to others. While the water usage in an area is small relative to the total quantity available then problems do not manifest themselves. In the absence of some form of collective action (say a charge on water), this model for water ownership encourages farmers to extract at too great a rate. As the abstractions approach the limit of the resource, the assumption of unlimited rights to water beneath the land leads to severe problems. Over abstractions arise and some families find themselves without water through no fault of their own. Salinisation of the aquifer also takes place and, in some cases, the water will be exhausted before crops are harvested with the associated economic penalties of a failed crop.

Low incomes and high electricity costs impose a burden for irrigation that creates difficulties both in terms of present-day livelihoods and the future maintenance of infrastructure. Members of the farmers associations simply stop contributing both in terms of finance and man-power in order to seek employment opportunities elsewhere. This tends to a lack of social cohesion. Reports of fraudulent activities carried out by members of water use committees in Rosário and Campo Alegre illustrate low levels of trust and cohesiveness. Social capital (the strength with which a community can work

together to solve problems and to support one another) has been singled as an important attribute of resource dependent communities (Adger, 2003a). Without trust, community members have no individual incentives to pool risks associated with the use of water resources. It is interesting to note that qualitative differences do exist between the types of bonds and relationships encountered in Mutuca relative to Rosário and Campo Alegre. In Mutuca, family ties are more evident and thus risk pooling (as well as the diversification of activities) is practiced to a greater extent than in the other areas. It appears that in Mutuca, households are more resilient to human-induced and environmental uncertainty than in Rosário and Campo Alegre, although this needs confirmation.

An argument can be made that farmers in the three communities are simply unaware of the CPR dilemmas they face. While it is certainly true that the issue of water availability is 'on the agenda' in the region (as exemplified by a recent water workshop organised by the NGO CEDAPP in Pesqueira), it seems that individual farmers are ill equipped to deal with the types of environmental risk and uncertainties that they encounter. The ways in which the communities begin to make sense of water as a common pool resource and develop collective, cohesive responses will be decisive for an increase in social resilience in the region.

Finally, opportunistic activities can also create problems for the communities and for the creation of social capital. Examples include individuals who choose to neglect their responsibility to support collective actions in favour of private activities for personal gain; the influencing of the distribution of subsidies and grants within the community; and the soliciting of favours or money to provide services to which people are entitled. Anecdotal evidence exists for these types of activity but it is unclear how widespread such abuses are.

The concepts introduced in this section have strong implications for the Project and will be carefully considered in each phase of the Project delivery.

3.6 The Role Played by Irrigation

In northeast Brazil, capital intensive irrigation for staple crop production is on the rise (Gomes, 2001). This export-oriented type of irrigation is limited to a few localities where water is plentiful. In these locations, irrigation systems typically yield 30% efficiency levels due to inappropriate water use management and more than 30% of all irrigated areas are affected by salinisation (Gaese, 2003).

Capital intensive irrigation systems are not a viable option for the vast majority of the semi-arid regions in northeast Brazil (Suassuna, 2003). Irrigation systems should serve a different purpose: they should allow smallholders (the majority of the rural population) to improve food security and their standards of living. A strategy to achieve this type of development has to consider three strands of action. First, irrigation efforts should be tailored to the different micro-physical environments encountered by the farming communities in Mutuca, Rosário and Campo Alegre. Second, the regional/local processes that act against collective action in these farming communities should be addressed. Finally, environmental uncertainty and climatic risk should be better understood and managed at the local level.

One way that irrigation can enhance food security and improve standards of living is by increasing crop productivity. This can be achieved by: (i) expanding the total area planted to crops; (ii) increasing yields per unit area or per individual crop; and, (iii) growing more crops per year (in time and space).

In the context of a limited water supply, the last two options seem the most viable for all three areas of the KaR Project. Yields may be increased by improvements in crop husbandry techniques, soil fertility management, rational crop selection, and mixed cropping techniques. The adoption of these low-technology, value-added techniques need to be further explored in the study areas. Non-governmental

organisations (NGOs) in Pesqueira have considerable experience in applying these techniques in the region. This knowledge should be used.

The factors affecting decision-making patterns by peasant communities living with high levels of uncertainty, described by Ellis (1993), appear to apply well to the study areas. Household farmers in Mutuca, Rosário and Campo Alegre face imperfect input/output markets, are highly resource dependent (i.e. subsistence is mainly derived from agriculture) and are subject to environmental variability and social uncertainty. Despite these similarities to the general picture presented by Ellis(1993), many peasants encountered within the study sites are not typically 'risk-averse'. Many are willing to take large risks in order to improve their livelihoods. This condition is especially true in Rosário where informal interviews with farmers demonstrated huge crop losses in the past. The important point is that there are qualitative differences between the ways in which farmers in the three study areas manage and interpet uncertainty.

In areas confronted with high levels of uncertainty, diversification is extremely important. Risk-spreading activities do not necessarily involve a trade-off against efficiency. They are often found to 'increase the productivity of resources when micro and seasonal variations in climate and soils are properly considered (Ellis:1993, 98). This argument is consistent with the notion of adaptive efficiency offered by development economists in the 1990s (North, 1990). The importance in diversifying activities (i.e. different crop mixes, farming and animal husbandry, etc.) as an insurance against environmental uncertainty is well documented in the development literature (Leach *et al*., 1999). Irrigation can serve both to alleviate the risk of drought between one season and the next, and to smooth out within season fluctuations of water supply to plants. In addition, it can permit higher productivity cultivation practices, such as multiple cropping, with a direct impact on the volume of output and farm incomes.

3.7 Initial Findings

The major findings that will influence the Project delivery include:

- The three study areas are diverse, both in terms of the water resources and social settings. In general the water situation during the drought period experienced during the past three years has been severe, while flooding in this year has caused significant damage to infrastructure.
- The exploitation of groundwater resources of the area could be termed haphazard, with numerous shallow wells being sunk in different properties in an attempt to maximise individual gain. Most of the wells in Campo Alegre were located in the alluvial deposits in or near the dry river bed. Nearly all wells were destroyed by the flooding. Groundwater exploitation close to the river arises once the surface waters are exhausted. The Groundwater dams in Mutuca have limited function. Numerous natural dams created by resistant basement rocks provide significant control on groundwater flows through the valley.
- High levels of curiosity in the Project and in initial availability to participate in the Project have been expressed by both local authorities and the local population. It is now important to maintain and stimulate this interest through specific actions which engage the communities positively in developing the groundwater resource.
- The challenge of full co-ordination and collaboration between the Project technical and social development teams is recognised and is a key factor for the successful outcome of the Project.

- There are several initial approaches to establishing water resources management within the communities in the three study areas that will be followed in the first instance. These should provide a framework for future development. They include strategies for establishing a user centred monitoring network arising out of the local associations; creating community level understanding of water optimisation in irrigated fields using appropriate and interactive methodologies being developed within the project; enhancing rainwater harvesting opportunities for rainfed agriculture and domestic water supply.
- There is a lack of a clear community basis for water management, other than the farmers associations (which are not fully functional) and a lack of government regulatory controls at the local level to support the empowerment of the local population.
- There is a need to engage both men and women in the water debate and to provide a greater focus on domestic level water supplies and the improvement of strategies for managing these. The broader issues of water consumption for all uses has been highlighted as an important alteration to the emphasis of the Project, whilst recognising that the main thrust of the study is concerned with agricultural water exploitation.
- There are complex differences between the three study areas in terms of physiographic, underground and demographic conditions. This calls for a sensitive approach to knowledge transfer that avoids the 'one size fits all' concept, while permitting clear messages to be exchanged without creating apparent inconsistency in style and knowledge spanning the three study areas.
- There are severe limitations to the exploitation of the groundwater systems, notably in Campo Alegre, and a lack of hydrological data that will allow for the characterisation of the study areas. Gathering new data using community based soils and groundwater investigations will provide a vehicle for infilling the missing information about the functioning of the resources and will provide a basis for an education programme that will allow the community to see in a holistic manner how the water environment is affected by drought, excess and human induced stresses.
- There are clear discrepancies between the high economic return for water as a commodity supplied to the local towns and as a resource for farm level activity where economic returns are relatively poor. This applies in particular to the exploitation of groundwater by private individuals during drought periods. Understanding how far national and local water policies can be developed to monitor conflicts and impose sanctions on the misappropriation of water will be important.
- The establishment of the Xukurú reservation, within which one of the major surface water reservoirs is located was celebrated by the Xukurú but deeply resented by the many of the Pesqueira city population. Non-Indian people believe the indigenous people to be violent and divided among themselves while the Xukurú believe that their former *cacique*, Chicão, was assassinated and his son, the present *cacique* threatened with death by members of the Pesqueira elite. Tensions are evident and dialogue between the Xukurú and the 'white' population is affected. In relation to water resources, the Campo Alegre area is affected by the lack of water releases from the Pão de Açucur reservoir, while it is unclear whether the lack of water transfers is due a change in operating policy for the dam or simply a problem created by the extended drought.
- The existence of a culture of grant aid (through material supplies and capital infrastructure – including for irrigation provided by government) has tended to undermine self development within the local community and breaks the link between effective water control and costs versus benefits within agricultural production. The zero cost attached to water is providing an imbalance in the economy that will need to be rectified progressively if community based management is to be effective.

- The social patterns and economic controls governing the migration of workers during drought periods reinforces problems due to a shortage of water by encouraging a lack of manpower investment in better managing and maintaining the environment. Wasted effort through this route limits the rate of development of efficient water use in the longer term.
- Lack of sanitation is a potential risk to health, particularly during wet periods. There is also a general lack of protection of wells, used for domestic use, from contamination.

3.8 The Project Team

The Project comprises specialists from the United Kingdom and Brazil. The Project team that started the Project comprised the following individuals:

Name	Role in the Project	Affiliation
Jan van Wonderen	Project Manager	Mott MacDonald
Dr. Adélia de Melo Branco	Social Development Specialist	Independent (formerly FUNDAJ)
Giselda Lira de Araujo	Junior sociologist	Independent
João Suassuna	Local Researcher (monitoring programme)	FUNDAJ
Prof. Abelardo Montenegro	Local Research Co-ordinator (Irrigation and Agronomy)	UFRPE
Prof. Suzana Montenegro	Local Research Co-ordinator (Water Resources Specialist)	UFPE
Manoel Costa Netto	Local Research Assistant	UFRPE
Taisa Almeida	Local Research Assistant	UFPE
Don Moore	Irrigation/Resource Management	Mott MacDonald
Nadia Ford	Environmental Scientist / Hydrogeologist	Mott MacDonald
Rae Mackay	Resource Development Specialist	The University of Birmingham
Patricia Stocker	Social Development Specialist	Independent

Reorganisation within FUNDAJ has resulted in João Suassuna withdrawing from the Project, which has removed the pledged link between FUNDAJ and the Project agreed at the conception of the Project. Attempts are in progress to include Mr Suassuna in the Project Advisory Panel.

MSc students from Birmingham University as well as from UFRPE and UFPE are involved in ongoing research within the study areas. The MSc students work, in most cases, on topics that have direct relevance to the understanding of the groundwater resource systems in the Campo Alegre and Mutuca study areas.

Sami Hotimsky, a Brazilian national, is undertaking a PhD study at the University of East Anglia and has agreed to contribute to the Project through his PhD work. The topic of his research is closely aligned with the goal, purpose and outputs of the research of the Project. Mr Hotimsky will spend six month in the Project area from October 2004 and will contribute to the implementation stage of the Project. An outline of his PhD Project is given in Appendix B.

The junior sociologist has been replaced by Liliana Cunha de Souza, a junior anthropologist, in June 2004.

4 Summary of Knowledge Review

4.1 Scope

The full knowledge review is presented in a separate report. This summary provides the essential elements of the review of direct relevance to the Project.

4.2 The National Context

4.2.1 General

Brazil is a large country, which occupies about 8.5 million km^2 of land with a population of nearly 170 million (IBGE, 2000). It is characterised by a great regional diversity not only in socio-economic development, but in cultural and demographic terms as well. The south and the southeast, the more developed regions where federal political power is concentrated, are characterised by the large presence of inhabitants with European and Asian origin (particularly Italians, Germans and Japanese). The north of the country is characterised by an indigenous population, the northeast by the presence of people of European and African origin and, to a lesser extent, indigenous people.

Approximately 10% of the total quantity of fresh water occurring at any one time in the world can be found in Brazil. This makes Brazil one of the richest countries in terms of fresh water. However, internal to Brazil a great diversity of climate and topography produces great variations in the distribution of water throughout the different regions. By association, large differences in economic potential and socio-economic and cultural conditions are observed and the issues that surround water availability play a large part in forging these differences. In Brazil there are regions that range from a great wealth of good quality water to semi-arid regions where droughts are common, but where there are also serious problems of pollution and floods (ANA, 2002). The World Bank (The World Bank, 2000) observes that among the most important water resources problems in Brazil, there are two that stand out because of their social impact and on which there is pressure on the Government to act. These are drought in the Northeast and water pollution which occurs throughout Brazil. The former constitutes a major challenge for Northeast Brazil in terms of regional development and in terms of poverty alleviation.

The economy of Brazil has a strong agricultural component. Land farming has significant potential both for producing food for local consumption and for international trade. However, for the extension of arable lands in many areas, climate conditions and the availability of water resources can be a problem. This is of particular concern in the rural Northeast where the region can be classified as semi-arid. Semi- arid areas cover about 70% of the total Northeast area of Brazil and 13% of the total country area (Rodrigues e Silva *et al.*, 1993).

4.2.2 National Water Policy

The present Brazilian National Water Resources Management System (NWRMS) has been established through the Law 9,433 introduced in January, 1997, which also defined the NWRP. In 2000, the broad institutional reform of the water resources sector was consolidated by Law 9,984, which created the National Water Agency (ANA- Agência Nacional de Águas). Prior to this, the water resources management system functioned based on the 1934 Water Code and afterwards through the inclusion of the NWRMS in the 1988 Constitution.

The following objectives of the NWRP were established:

- to ensure the availability of water needed, at standards of quality appropriate to the respective uses, for present and future generations;
- to support the rational and integrated use of water resources, including waterway transport, with a view to sustainable development;
- to assist in the prevention of and protection against critical events of a natural origin or resulting from the inappropriate use of water resources.

The NWRMS is intended to coordinate integrated management of waters; to implement the NWRP through planning, regulating and controlling the use, conservation and recovery of water resources; to administer conflict, and to promote billing of water use. The members of the NWRMS include the water resources councils at national, state and federal levels, river basin committees, water agencies and other government agencies concerned with water resources management. The basic principles underpinning the NWRP may be summarised as follows:

1. Water is public property;
2. Water is a limited natural resource, which has economic value;
3. When there is a shortage, priority in the use of water resources is given to human consumption and the watering of animals;
4. The management of water resources should always allow for multiple uses of water;
5. The river basin is the territorial unit for the implementation of the National Water Resources Policy and the actions of National Water Resources Management System;
6. The management of water resources should be decentralised and should involve participation by the Government, the users, and the communities.

4.3 The Regional Context

4.3.1 General

The northeastern region of Brazil occupies about 1.54 million km², which comprises the states of Maranhão, Piauí, Ceará, Rio Grande do Norte, Paraíba, Pernambuco, Alagoas, Sergipe and Bahia and occupies about 18% of the nation's territory. The 2000 census indicates that the population of the region is 28% of the national population, or about 48 million inhabitants. The Northeast is therefore one of the most populated regions of the country, with a population density of 31 inhabitants per km². The region is characterised by the occurrence of periodic droughts and is the poorest region of the country and one of the poorest of the world. Income and wealth are very unequally distributed and the quality of life of the majority of the population is very low.

4.3.2 Climate and Water Resources

Although Brazil can be considered as one of the countries of the world, which has amongst the largest water reserves, mostly due to the water available in the Amazon Basin, the country faces many problems related to scarcity of water. The northeastern and a small portion of the southeastern states of Minas Gerais and Espírito Santo are characterised by a semi-arid environment and are severely affected by water shortages.

The Northeast of Brazil is principally characterised by its climate, although geological and pedological controls play an important role in defining the hydrology of the region. The major part of the region lies in the so-called “drought polygon”, being associated with relatively low precipitation, and high evaporation rates. The total area of the “drought polygon” is estimated to be one million km^2. The rainfall regime in the region is highly irregular, with precipitation concentrated in three to four months per year, between November and June. In the central area of the ´drought polygon´ the average annual precipitation is less than 500 mm (Matsui,1978).

The problem of water shortage in the semi-arid Northeast of Brazil is also linked with the geological variations across the region. Hydrologically, the Northeast of Brazil can be separated into two parts: the lands overlying Precambrian crystalline basement rocks and the lands on the sedimentary basins (Audry and Suassuna, 1995). The main features of the crystalline basement are shallow soils with low infiltration capacity, and low storage potential. As a consequence, most of the rivers and rivulets crossing these geological units are non-perennial, with occasional flooding during the wet season and dry during the summer period. The groundwater resources of these areas are restricted, with aquifers being limited to fissure zones and to the narrow river alluvial deposits (Audry and Suassuna, 1995). The alluvial aquifers in the crystalline environment have a considerable importance as an exploitable water resource for the populations that reside in these areas but the resource is strongly limited by the geological conditions and management of the resource is essential to maximise its value. In many of the states of the region, the crystalline basement rocks occupy greater than 70% of the total area (Audry and Suassuna, 1995).

The sedimentary basins are comprised of deep soils and generally permeable rocks with relatively high infiltration capacity. Rivers on the basins are perennial and the groundwater resources are abundant with the sedimentary formations creating deep and extensive aquifers.

Given the climate and geology, irrigation practices in the Northeast of Brazil incur a relatively high risk of soil and water salinisation. This is one of the factors that classifies the region as having a high risk of desertification.

4.3.3 Legislation and Institutions

The water management in Pernambuco State has been developing under state law Nr. 11,426 since 1997. The acting legislation institutes the Integrated Water Resources Management System – SIGRH/PE, composed of the following:

- Regional Water Resources Council (CRH).
- State Water Resources Committee CERH).
- River Basins Committees (CBH) and User Associations. They have as their main objectives the promotion of the rational use of the water, the protection of the water source and the avoidance of conflicts of uses and/or among users.
- Secretariat of Science, Technology and Environment of Pernambuco State (SECTMA). Its aim is to promote the social, economics and environmental development of Pernambuco State by the formulation and implementation of integrated public policy of technological innovation, higher and professional education, science development, environmental protection and conservation.
- Other executive institutions (ITEP and CPRH). ITEP (Pernambuco State Technological Institute) supports the activities of meteorological and climate monitoring, while CPRH (Water Resources and Environment State Agency) is responsible for licensing the use of water, water resources and environment monitoring, development of environmental and water resources education programme;

4.3.4 Hunger Zero Programme

Being the poorest region of Brazil, the semi-arid region of the northeast has received a lot of attention from governmental programmes. In order to improve the livelihoods of the population and to avoid the out-migration of rural poor to large urban centres, the Federal Government is implementing the Hunger Zero Programme to benefit the rural poor by fighting poverty through the eradication of hunger. The Programme provides R$50 per month to each of the beneficiary families (families with an income of less than $R100 per month) to be utilised for the purchase of food. Within the context of the Hunger Zero Programme, there are related programmes and one of those is the Thirst Zero Programme.

4.3.5 The One Million Cisterns Programme

This is a programme to address the problems related to the scarcity of water faced by the majority of the population in the northeast region. Among the actions implemented by the Thirst Zero Programme is the One Million Cisterns Programme (referred to as the P1MC), which was initialised during the tenure of the previous government. It continues to be an important means of benefiting the rural poor from the semi-arid through the construction of cisterns and the stimulation of the use of rainwater harvesting for household consumption as well as for agriculture.

The P1MC is innovative in many ways, not only for focussing on the needs of the poor but for stressing the importance of education as the basis for all its actions. The Project can be seen as the broadening of the experiences of civil society organisations throughout the years. NGOs have been working closely with local communities in a search for solutions to the problems of the scarcity of water. The harvesting of rainwater appears to be very promising not only due to the possibility of harvesting water for critical drought periods, but especially for allowing and facilitating the introduction of an effective and permanent process of social organisation and mobilisation for water management.

The main goal of the P1MC project is to contribute, through an educational process, to a social transformation in the region. Through the provision of water and the ‘empowerment’ of the most vulnerable population, the project expects to introduce new patterns of social relations distinct from the old patron-client relations between the poor and the wealthy, which have been characterising the semi-arid region for a long time. The project thus considers the preservation, the access and the management of water as a right and an obligation of every citizen. In such a context, the project broadens the understanding and the practice of “dealing” with the problems posed by the semi-arid ecosystem in a sustainable way.

An important aspect of the project is that it is the result of a partnership between civil society organisations and the government. The local NGOs that first proposed the project were successful in influencing the government about the importance of the actions and have been receiving the support from governmental institutions such as, ANA – The National Water Agency, which is part of the Ministry of the Environment. Owing to this partnership the project has been receiving funds and is finalizing the construction of 12 400 cisterns devoted to fulfil the needs of the families in the semi-arid region. The construction of 22 040 more cisterns has been initiated in the next phase. The project aims at constructing one million cisterns in a five year period (ASA, 2002).

Water scarcity has also been receiving the attention from the Catholic Church through the annual solidarity campaign of CNBB – The National Conference of the Bishops in Brazil. The theme in 2004 is “Water as a Source of Life”. The Church is trying to raise funds to be used in the construction of wells throughout the semi-arid region.

4.3.6 Socio-economic Profile

In order to understand the current situation of those living in the northeastern region, it is important to consider the regional development through a historical perspective. Whereas the region was the most important political centre and the wealthiest part of the country during colonial times, it is now the poorest and least developed in the nation. Such a change was due to the fall in economic importance of sugar, the basis for the economy of the area. Up until the nineteenth century, the Brazilian Northeast was one of the most important sugar producing areas in the world. Slaves were brought from Africa by the Portuguese to work on the sugar plantations. At the end of nineteenth century, the regional economy began to deteriorate as a result of the fall in the price of sugar in the international market. From that time on, other regions such as the south and southeast became the economic centres of development being exposed to the industrialisation process, whereas the Northeast was exposed to an economic stagnation.

The Pernambuco state, where the KaR Project is being implemented, was one of the main sugar cane producing areas during colonial times. Pernambuco is located at the centre of the northeast region. It covers an area of nearly 100 000 km^2, and has a population of about 2.7 million, and a demographic density of 27.4 inhabitants per km^2.

Pernambuco is characterised by three distinct sub-regions: the humid coastal area, i.e. the *Zona da Mata*, the transitional area, i.e. the *Agreste* and the semi-arid hinterlands, i.e. the *Sertão*. The humid *Zona da Mata* covers 11% of the area, whereas the transitional *Agreste* occupies 19% of the state and the dry *Sertão* covers 70% of the state land.

In economic terms, the *Zona da Mata* still concentrates on the cultivation of sugar cane and the *Agreste* and *Sertão* concentrate their economic activities primarily on cattle breeding and agriculture. The land tenure system is also distinct in the three sub-regions. In the humid *Zona da Mata*, there is a high concentration of land in the hands of a few, the *Agreste* is characterised by the presence of both small and medium landholdings and a few large holdings and the *Sertão* is characterised by the presence of large landholdings. As the pressure over land increases and the governmental response in regards to land has failed to adequately address the considerable deprivation of the rural poor and landless, several social movements have become organised and have been mobilizing the landless population towards a struggle for land. Conflicts have arisen in several parts of the state as the landless population occupies properties they consider to be unproductive. The most important and strongest of the social movements supporting these actions is MST – The Landless Movement, which has also been responsible for the highest number of land occupations in Pernambuco.

The situation of the poor population which inhabits the Northeast is very difficult. Owing to the high unemployment rate and the periodic droughts, which affect particularly the *Sertão* and parts of the *Agreste* sub-regions, many abandon the rural sphere and head to peripheral neighbourhoods in medium sized cities in the region and others migrate to large urban centres in the southern and southeastern parts of the country. The government has been unsuccessful in keeping the population of the Northeast on the land. When land is provided, it does not seem to be enough as the environmental conditions of the area are a limiting factor for the rural people to meet their survival needs. They lack sustainable means to work the land under severe drought conditions. In such a scenario, the model of land reform, which has been implemented by the government, has proven unsatisfactory as the provision of land alone is not enough to keep the population in the rural areas. Appropriate conditions to work the land as well as to market the produce have to be offered. The government has tended to focus its attention on large-scale irrigation schemes, such as the one on the margins of the São Francisco River.

The São Francisco Region is located on the margins of the most important river found in the semi-arid region. The availability of good quality water, appropriate soil for agriculture as well as many hours of sunshine a year contribute to the successful cultivation of irrigated crops. Therefore, the area produces

fruits and vegetables for the national market and for export. This has attracted migrants and investments to the area and has turned it into one of the most developed agricultural regions in Brazil.

4.3.7 Socio-economic Setting of Pesqueira Municipality

The municipality of Pesqueira, the site of the KaR Project, is located in the Agreste sub-region of the Pernambuco state and occupies an area of 1 032 km^2. Pesqueira has a population of 57 602 inhabitants, 27 763 of whom are men and 29 839 women. The urban population is comprised of 40 892 inhabitants and the rural population accounts for 16 710 inhabitants (IBGE, 2000). The urban population is much higher than the rural as is the case of most municipalities throughout Brazil. It reflects the out migration of people from the rural sphere. The demographic density in Pesqueira is 56 inhabitants per km^2.

Although the municipality shares most of the characteristics of medium sized cities in the Agreste, it has some unique characteristics. Pesqueira was once a very important cultural centre in the region. Many of the elite members of society from surrounding cities used to send their children to boarding school in Pesqueira. In demographic terms, besides the presence of the afro-Brazilian population, which forms the majority in the Northeast, the area is the place of origin of the Xukurú Indians. Pesqueira also had two industries, the most important of which was the Peixe, an industry devoted to the production of tomato sauce and fruit jelly. Besides actually processing the vegetables and fruits, Peixe owned large areas of land where the crops were cultivated. The Peixe industry played a major role in the economy of the municipality and the region as a whole as it employed a large number of people from both urban and rural areas. The Peixe industry was known as Carlos Brito Indústria Alimentícia S.A. and was owned by a local family. The industry was exposed to bankruptcy at the beginning of the 1990´s and the municipality was severely affected. In order to pay for the debts owed to the state government, the Peixe industry was obliged to forfeit its land in 1992. In 1996 the government decided to transform the area once owned by Peixe into *assentamentos* so that the former workers, who were landless, would be able to receive indemnities in the form of land to cultivate. This is discussed in more detail in Section 4.4.5 as the Project is being implemented in two of these areas.

The local political setting in Pesqueira is very traditional. The mayor belongs to PFL – The Liberal Front Party, which is the right wing conservative political party in Brazil. The Catholic Church has a strong presence and both NGOs based in the municipality are related to the Church. CEDAPP – The Support Centre for the Small Farmers works in a variety of areas in the rural sphere of Pesqueira and the surrounding municipalities. They have several funded projects on environmental issues, including water and renewable energy. The other NGO is CARITAS, which covers activities throughout Brazil.

The most important economic activities in Pesqueira are agriculture, cattle breeding and poultry. Beans, corn, manioc, tomato and guava are the most important crops produced. Poultry has become important in recent years due to financial incentives received by small landowners to engage in this activity. However, the local economy is not restricted to these activities. The municipality also has small-scale factories producing jelly, dairy products, and, to a larger extent, furniture. The wood used in the manufacture of furniture comes from the northern state of Pará. Another very important source of income is lace making and embroidery, activities which have been predominantly female, but which are increasingly being performed by men due to high unemployment rates. Women from both rural and urban areas complement their household income through the production of lace artefacts and sell their products in the local market. In times of severe drought, this activity acquires great importance. Although the profit made from lace making is not high, the fact that it is stable makes this activity very important. In this context, the women play a very important role in the society. In contrast with most rural areas throughout the Northeast, where women do not have any skills and are thus dependent on their husbands, the women in Pesqueira benefit from lace making. This can be seen as a form of empowerment for them as women become respected for providing some income to support the family. The importance of lace making is higher in areas where the work opportunities are fewer.

Until recent times, tourism could also be considered as another important economic activity in the municipality. Oral historical accounts of the Cimbres Sanctuary where the Virgin Mary appeared to three local children many years ago, attracted religious tourists to the municipality. This activity has decreased in importance since 1998, when the area, where the Sancutary is located, became part of the Xukurú Indian Reserve. The Xukurú have restricted the flow of tourists to the area and this has caused some tension between the Pesqueira population, the municipal government and the Xukurú Indians arising from a loss of income to the region.

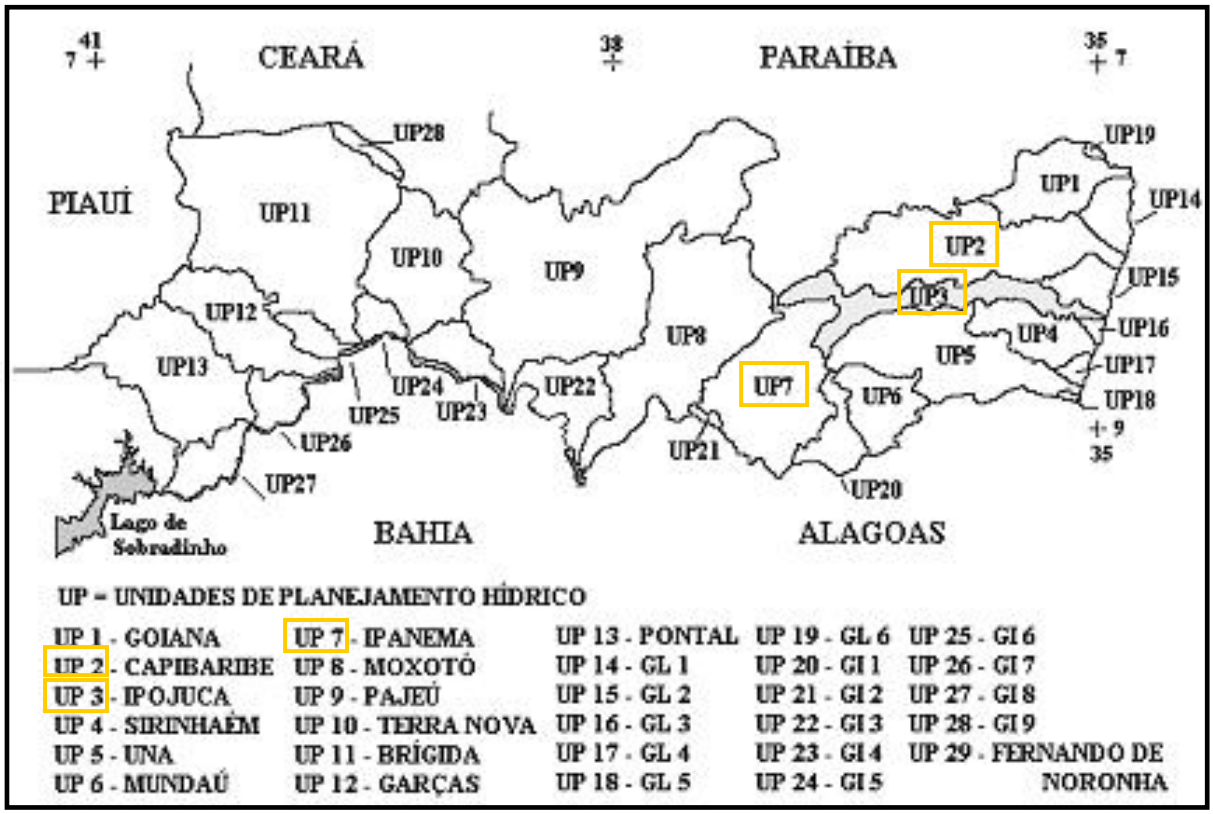
4.4 The Study Areas

4.4.1 Physical Setting

To support agricultural practices at relatively low cost and with minimum environmental impacts, small scale communal irrigation areas have been established in Brazil over the last 20 years. Brazil's Government agencies are responsible for the execution of this initiative, the installation of a basic infrastructure, the management of the system, and the provision of technical support to the farmers. The farmers, based on the directives of the projects under this initiative, are responsible for the cultivation and harvest of the crops. In addition, the Government agencies should carry out field surveys at the irrigation sites to continuously check relevant aspects which may affect the performance of each project, such as water quality and quantity, and soil conditions for cropping. However, a lack of financial resources usually constrains monitoring at project sites. Many of the projects in the semi-arid Northeast of Brazil are based on the use of the water from the localised alluvial deposits, which are found adjacent to the small streams that traverse the region. The selected study areas are located along ribbon valleys in Pernambuco State that traverse the crystalline formations which underlie more than 84% of the land area.

For water resource management purposes, Pernambuco State has been divided into 29 UPs (water resource planning units), which relate to single watersheds or groups of small watersheds (Figure 4.1).

The study areas are all located in the municipality of Pesqueira in the transition zone between `agreste´ and ´sertão', in the semi-arid region. The study areas are located in three different watersheds: Mutuca valley is located in the Capibaribe River basin (UP2), Mimoso valley is located in the Ipanema River basin (UP7), and Campo Alegre is located in the Ipojuca River basin (UP3).



4.4.2 Climate

The climate in all three study areas is similar to that monitored at the Pesqueira Meteorological Station, located approximately 15 to 20 km from the study areas. In Table 4.1, the main climate variables compiled from a 30 year period are presented. Rainfall is unevenly distributed, with 75% of the annual precipitation rates falling in 6 months (from January through to July). The dry season – from September through January – accounts for about 47% of the annual evaporation. The temperature distribution is typical of a semiarid zone, with high temperatures and little variation. The annual maximum temperature is about 29°C and the minimum is just less than 18°C.

The annual average relative humidity is 75%, with the highest values after the rainy period (May - July) and the lowest values in the dry period (September - November). Insolation reaches a value close to 2400 hours per year, which means a daily solar incidence of about 5 hours uniformly distributed throughout the year. About 19% of the annual insolation occurs from May to July. Winds are predominantly south-western with moderate wind velocities less than 4.4 m/s: the greatest wind speeds occur in the dry period.

Table 4.1: Pesqueira Station Main Climate Parameters (30 year period).

Parameters	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	Total/ Average
PREC (mm)	51	91	86	121	101	81	72	37	23	19	18	29	730
TEMP(^{o}C)	25	24	24	23	22	21	20	20	22	23	24	24	23
ETP(mm)	164	147	153	133	122	106	110	125	140	159	160	163	1683

(PREC= average rainfall; TEMP= average temperature; ETP= potential evapotranspiration) (Irrigation project of 'Nossa Senhora do Rosário' farm (CISAGRO, 1990)).

4.4.3 Hydrogeological Characteristics of the Study Areas

The location of the three study areas are shown in Figure 3.1, while more detail is shown in Figures 4.2 and 4.3.

(i) Mimoso valley

Characterisation of this valley is well advanced through the long term development of a communal irrigation project located at 'Nossa Senhora do Rosário' *assentamento*, in Mimoso valley. The *assentamento* lies in a gently sloping watershed. The average altitude is 630m above sea level, with an average natural slope of 0.3% in the line of the valley. The flat topography controls the natural drainage of the system. The watershed stream network comprises the 'Mimoso', 'Ipaneminha' and 'Jatoba' rivulets. The 'Mimoso' is the main rivulet of the watershed, being connected to the aquifer along its length. These rivulets are ephemeral, flooding the area during wet rainy seasons, and becoming dry for several months in the dry season. The use of the surface water resources, which are regulated by means of small dams, has been restricted to domestic supply to the nearby cities. Thus, the groundwater is the only suitable source of water for irrigation.

The underlying alluvial aquifer is relatively shallow, about 10m deep, 300m wide and 15 km long. The aquifer is a fine to medium sand deposit, with some clay lenses. The water table in the area is relatively shallow, with depths ranging from 2 to 5m. Previous hydrological studies have indicated values between 160,000 and 300,000m^3 as the annual exploitable water resource in the aquifer (CONESP, 1988; Montenegro, 1997). The average hydraulic conductivity has been found to be about 5-6m/day and the specific yield is 6% (CONESP, 1988). The relatively high hydraulic conductivity has allowed aquifer exploitation by open wells, connected to lateral multilevel drain tubes (radial collectors). This kind of well has been shown to be suitable for exploitation of very shallow aquifers, producing good performance at relatively low rates of water table drawdown. The original irrigation project for the area included the installation of four wells, 10m deep and with 3m diameter, although currently many other open wells of larger diameter have been built by the farmers. Directives for exploitation of the aquifer using the wells have been issued based on preliminary hydraulic tests.

Pedological investigations have been carried out in the 'Nossa Senhora do Rosário' *assentamento* area in order to adequately identify the soils with potential to be irrigated, mainly from the point of view of drainage and water transmission. The total area of the survey constitutes 173.6ha. The soils in the study area are classified into five groups: alluvial, yellow red podzol, regosol, litholic and gleyed.

Table 4.2: Soil Groups and Units in 'Nossa Senhora do Rosário' Assentamento

SOIL GROUP	SOIL UNIT	AREA (ha)
Alluvial	Ae	38.2
Regosolic (Entisol)	REe1 REe2	18.8 46.6
Red yellow podzolic	PE1	29.8
Litholic	Re1	26.9
Gleyed	HI	13.3

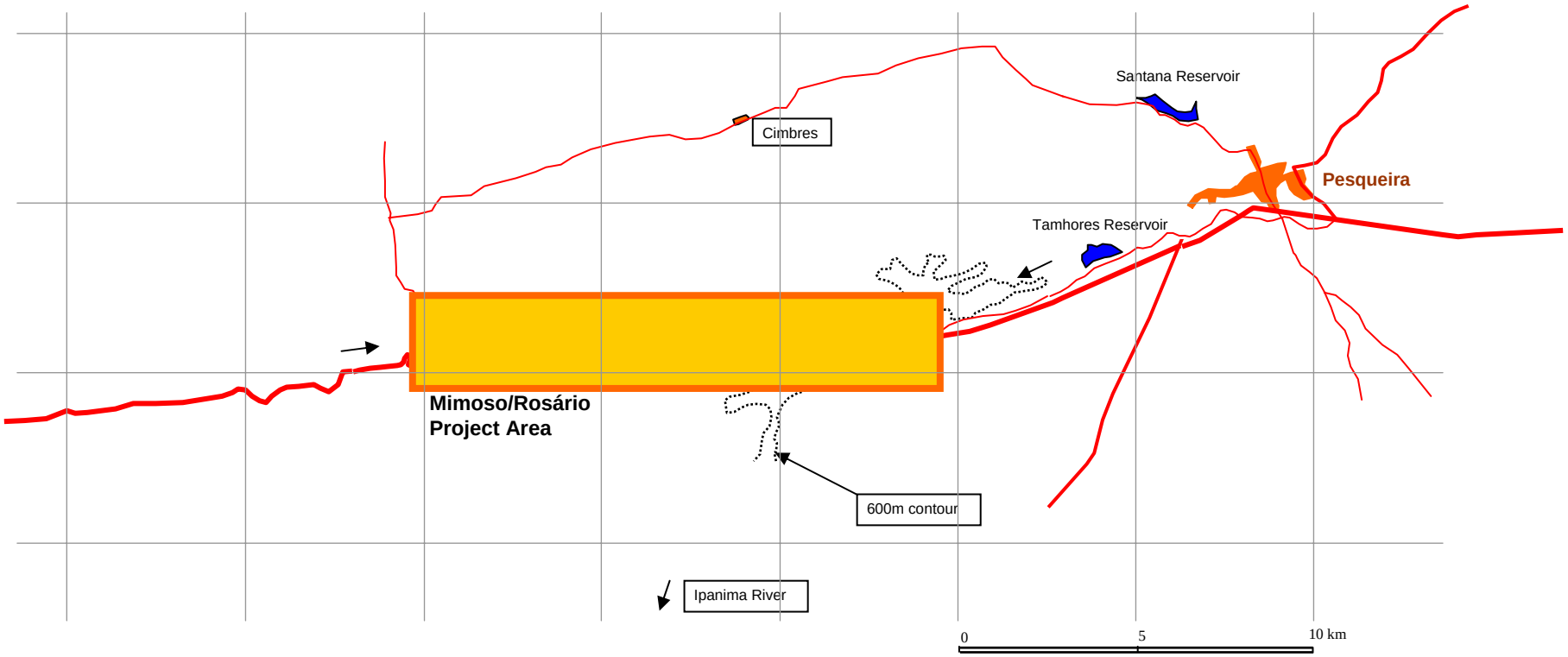


Figure 4.2: Mimoso/Rosario Project Area

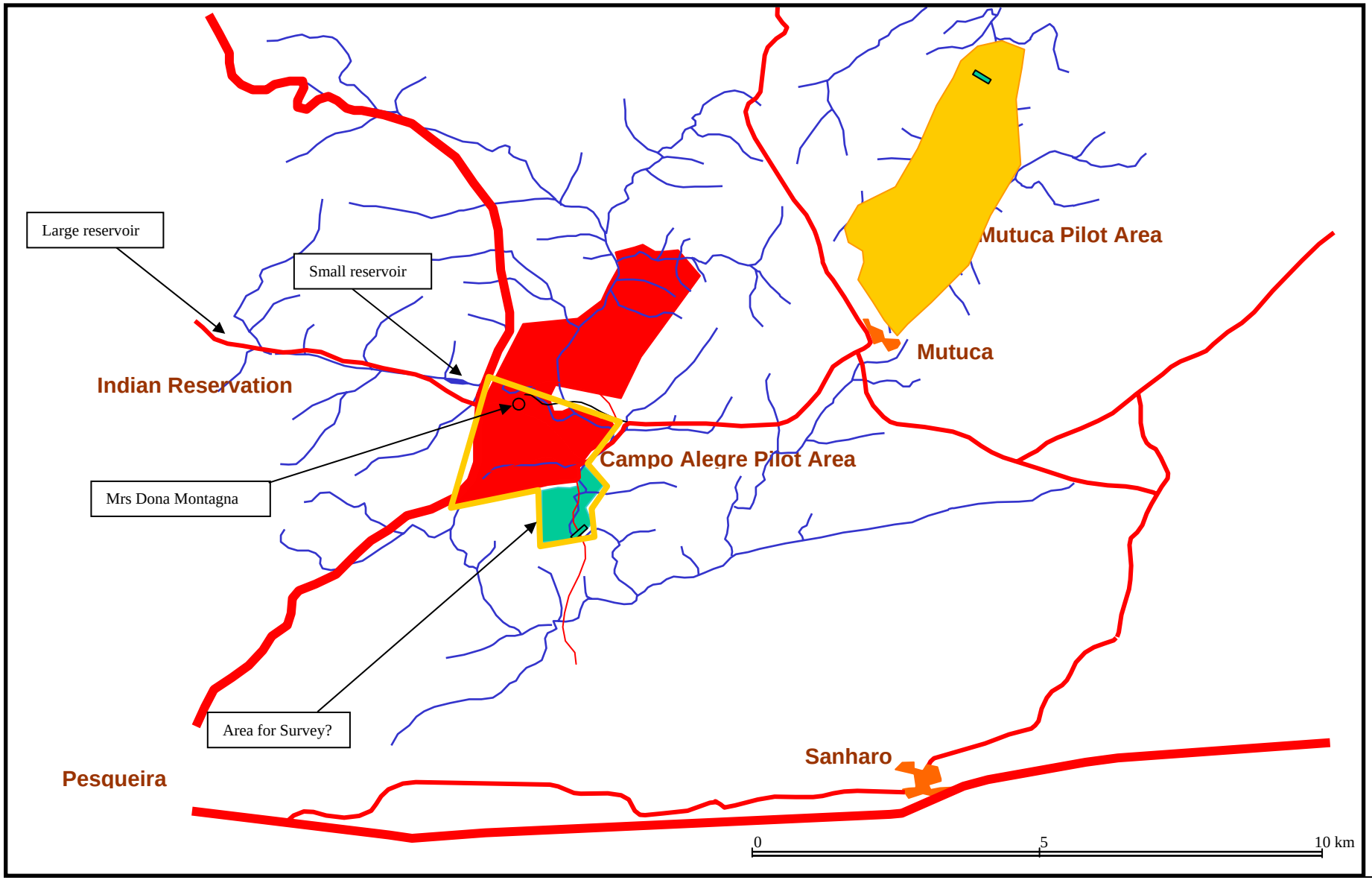


Figure 4.3: Campo Alegre and Mutuca Study Areas

Additionally, a land classification study for irrigation has been completed. The land characteristics in the area have been described according to U.S. Bureau of Reclamation (US Soil Conservation Service) criteria, and account for use, potential yield, depth, topography, drainage conditions, water availability, ploughability and development and production costs.

The total area of 'Nossa Senhora do Rosário' *assesntamento* is 606 ha, with only about 100ha potentially suitable for irrigation. The irrigation project's design indicates that of this area, only 32ha could be effectively irrigated, given the limited water resources and suitability for agricultural practices. The total area of the project has been divided into four sectors, each being supplied by one of the four wells. The four sectors are divided into a total of 24 plots, of about 1ha each, making up the portion of irrigated land in the farm. The main crops cultivated in the area are tomatoes, cabbages, beetroots, carrots, peppers and green peppers. The directives adopted by the irrigation project dictate that cultivation begins in September with harvesting in December for most crops. The crops are irrigated daily. Although a subsurface drainage network has been designed for the irrigated area, to date it has not been built. The farmers in 'Nossa Senhora do Rosário' *assentamento* are organised into a cooperative group to facilitate technical assistance from the Government.

For characterisation of the salinity distributions in the alluvial aquifer, 80 piezometers have been installed on the farm area (Mackay and Montenegro, 1996). These piezometers have depths ranging from 5 to 8 metres and separation distances from 5 to 2500m. Water samples have been monthly extracted from piezometers since 1995, when they had been installed, allowing the analysis from the water table depth and electrical conductivity of the water in the saturated porous media (ECw).

The upstream area is characterised by sandy soils with little clay, but the clays increase significantly downstream. The upstream area has good drainage caused by natural soil units while downstream the soil drainage is more restricted. The link between geology and pedology is apparent in this simple observation (Montenegro et al, 2001). According to the available soil salinity the salinity is also strongly correlated to the geology but is also partly linked to the inputs of water and salts from the stream tributaries that join the main stream.

(ii) Mutuca

Mutuca study area is located within the Belo Jardim municipality, although Mutuca village is located within the Pesqueira municipality. The area contains 10 underground dams, built by the Pernambuco State Government in 1999, along the alluvial valley of the Mimoso rivulet (in the Capibaribe river basin). The valley is located in the border between Jatauba (to the north) and Belo Jardim municipality and is covered by a large percentage of planosols. Although the valley sediments are relatively deep (from 4.0 to 10m), impediment layers restrict direct recharge. Groundwater storage is partly controlled by the underground dams and partly by natural barriers to flow along the valley where harder basement rocks occur close to the bed of the river. Irrigation is practiced primarily using the groundwater reserves upstream of each dam. Besides monitoring along the valley and investigations on recharge mechanisms (Blackburn et al., 2002), a pilot area has been installed with micro-sprinkler irrigation, just upstream from one of the dams. Montenegro et al. (2003) detail the hydrogeological behaviour of this unit, and the irrigation impact on water quality.

According to Montenegro et al. (2003), loam and sandy loam soils are dominant at surface. Infiltration tests have been conducted across the area, producing an averaged infiltration rate of 90 mm/day. Such low infiltration characteristics require careful irrigation management and low irrigation water depths. Soil electrical conductivity monitoring during the dry season in 2003 indicated that around 35% of the total samples analysed exhibited values greater than 4 dS/m, requiring salt management.

(iii) Campo Alegre

Campo Alegre is the least well characterised of the three study areas. It is physically distinctly different to both of the other two study areas in that the alluvial sediments are constrained in a much narrower valley. The Campo Alegre area presents undulating relief and valleys with relatively steep sides and occurrence of narrow alluvium bands. The relief has been moulded by morphogenetic forces that created the geomorphological unit of Borborema Formation. The rocks that constitute the original material of the majority of soils are acid plutonic, being mainly found Saprolite of biotite-granite. Predominantly, sandy sediments of alluvial-colluvial nature occur, attributed to the Holocene period, in narrow plain land bands on the edges of the Ipojuca River. All the irrigation area has already been deforested. Only isolated points of the remaining typical vegetation of Caatinga can be found. Groundwater is highly saline in the dry season, limiting crop production and irrigation.

The study area is located in the part of the catchment downstream from the eastern boundary of the Xukurú reservation. Near the headwaters of the catchment on reservation land is the Pão de Açucar reservoir. This is the largest reservoir in the region and has a major controlling influence on the transmission and retention of waters in the river system.

Historically, waters were released along the river from the Pão de Açucar reservoir, and these certainly were exploited for irrigation. Since the start of the drought in 1988, the flows on the river have been significantly reduced and groundwater exploitation from the alluvial deposits was expanded to compensate the reduction in surface flows. Most of the wells excavated in the alluvium were destroyed during the recent heavy floods. Several dams/weirs are located along the river corridor, which impede surface and subsurface water flow. The impounded waters upstream of these structures provide surface water for irrigation during the rainy season and groundwater exploitation as the surface waters recede in the dry season. The alluvium cannot sustain groundwater supplies indefinitely during drought periods and the water becomes strongly salinised.

Streams contributing to the river have been dammed to construct small water supply reservoirs in some parts of the catchment. Rainfed agriculture is extensively practiced and significant areas of Palma are being cultivated for cattle fodder. Rainwater harvesting on these agricultural areas is restricted. Soils in the area are typically thin, overlying regolith, and these have limited moisture holding capacity. Livestock farming is a major component of the land use of the area. Some rainwater is trapped behind earth embankments for livestock watering.

4.4.4 Socio-Economic Setting

(i) The Xukurú Indigenous People

The Xukurú is formed by a population of approximately nine thousand indigenous people who live in twenty-four communities in a reserve with an area of 27 555 ha stretching westward and northward from Pesqueira town. The Xukurú are neighbours both to the Rosário *assentamento* to the south and to the *assentamento* of Campo Alegre to the east. One of the most important sources of income of many Xukurú is the production of crops, which are sold in the town market. Despite their integration within the larger society, the Xukurú have been able to maintain their own traditions with regards to their social organisation and beliefs. The Reserve has several schools, and the teachers as well as health workers are all from the Reserve.

The Reserve was recognised by the Federal Government in 1998 and has received attention from FUNAI – The National Indian Foundation. The tensions between the Xukurú and the Pesqueira population are not only due to the limited access to the Cimbres Sanctuary, but also to the fact that the Reserve occupies the most fertile land in the area, where the most important surface water reservoirs are also found. The *Pão de Açucar* reservoir is the largest of these reservoirs with a capacity of 34

million m^3 (acc. COMPESA). The reservoir dam was built in 1986 with the goal of providing water to the city of Pesqueira. However, the reservoir has not been fully utilised as main water supply source to Pesqueira in recent years, in part due to the lack of a pipeline connection to the town. Obtaining a downstream water supply from the reservoir was achieved via controlled downstream releases through the dam, into the Ipojuca River, with a much smaller secondary barrage located further downstream, allowing water to pool for the irrigation purposes of the Xukurú farmers. The outlet control from this reservoir to downstream users such as those in Campo Alegre, is thought to rest with the Xukurú, although the exact nature of control over the reservoirs is uncertain.

As a result of the characteristics of the land occupied by the Xukurú, their relationship with the large landholders who owned the land prior to the legalisation of the Reserve has been very difficult and has been characterised by violence. There are also some conflicts between the local political and economic elite and the Xukurú. The neighbouring communities are very suspicious of the Xukurú. The small landholders fear that the Xukurú are not willing to collaborate with the non-indigenous population in any respects, including access to the water reservoirs found in the Xukurú area. The Campo Alegre *assentamento*, one of the study areas, is located to the east of the Xukurú Reserve.

(ii) Rosário

The *assentamento* of Rosário is located in the Mimoso Valley, a very rich area in terms of the availability and quality of water. The Mimoso Valley is one of the few areas where groundwater is commercially exploited, especially during drought periods. The groundwater is not only of good quality but is available throughout the drought period. Rosário covers an area of 592.7 ha and this land was divided into sixty *parcelas* i.e. plots. Fourteen of these plots, i.e. 25%, are found in the ownership of women. The majority of the dwelling houses on this *assentamento* are grouped together in a village which, like other villages, has a school and a church. The State Institution responsible for the initial organisation of the *assentamento* was FUNTEPE – The Pernambuco Land Fund. The sizes of the plots vary slightly with most around five to seven hectares.

Part of this land is referred to as *várzea (*flood-plain), and is the most appropriate land for irrigation. Each of the *assentados* has one hectare of this type of land. They also hold a larger area, which is considered by the them as drought-prone, as it is not suited to irrigation The *assentamento* has benefited from several investments, in the form of grants, for the construction of wells and irrigation equipment, a dairy factory (which has never worked), and the purchase of a community tractor (which is managed by the local Association). The State Government also provided funds for community electrification.

Even though the beneficiary families do not have title to the land they occupy, they were encouraged to apply for loans to invest in the infrastructure of their plots and in the purchase of animals. Most of those who identified themselves in the socio-economic survey as *assentados* and *parceleiros*, i.e. those who do have access to land, mentioned that they received loans and had problems repaying them. Owing to the availability of the funds either through loans or grants, Rosário benefited and has a high number of wells and a high number of irrigated plots.

Despite the high investments and attention from the Government, Rosário has had several problems since its beginning. In 1992, many of those who occupied the area were former Peixe employees. However, when the State Government decided to turn the area into an *assentamento* in 1996, many of them had left and had even sold the plots without documentation. Land continues being sold and the price is given according to the plot's infrastructure (fences, wells, houses, etc.). A plot of land in Rosário costs from R$7.000 to R$10.000. This situation causes serious problems to the area and its social organisation as the families who sell their plots and migrate to other areas, tend to return to the community and form the masses of *"moradores"*, i.e. the landless. Besides holding return migrants, Rosário is also the home of the settlers´ offspring, who usually stay on after marriage. According to a

FUNTEPE employee, Rosário has become a *favela rural*, i.e. rural slum and although it was planned to hold sixty-one families, it now has a population of approximately one hundred families.

Rosário residents are not united and there are several community factions. This lack of unity existed even at the initial stages of the *Assentamento*. At that time, people were encouraged to form an Association. According to the Rosário population, the first elected Board had problems as the dwellers mistrusted the Board members and accused them of theft. The next elected Board has been in power for ten years. Furthermore, although the current President of the Association is an *assentado*, he does not live in the community and, as a result, does not participate in community life. He is not well liked and is one of the financially better off individuals in the community. Membership of the Association is decreasing and among the members only very few pay the monthly fee, which is R$2.00. Owing to the ineffective role of the Association in raising the population's consciousness about their rights and the importance of mobilising politically, and in bringing the population together to improve the living conditions at the *assentamento*, the majority of Rosário dwellers are apathetic and are not worried about collective projects but only think about their individual needs. The behaviour of the community members reflects the top-down nature of government assistance and the lack of opportunity these people have had to be heard. They were never consulted about which projects should be implemented in the community, neither did they mobilise to get them.

As in most communities, the poorest of the poor, who are usually landless, are very difficult to approach. Those people have to work for others and are usually not available to participate in meetings. This poses severe limitations for their integration and inclusion in community life and in projects that would help them improve their quality of life. In many cases, the most destitute population is excluded from benefits because they are not "visible", that is, those in charge of the benefits do not know who they are or where to find them.

An interesting factor about life and the social dynamics between community members and resources is that despite all of the problems with community rivalries, there is no dispute in regards to water and this resource is shared with those in need whenever it is necessary. This is the case only in regards to drinking water not water for irrigation or livestock. It is very understandable why only drinking water is shared with those in need as the energy used to pump water from the wells is paid for and it would not be fair to pay for water to be utilised by others in irrigation or for animal consumption, which are income generating activities

The Neighbouring MST – Landless – Squatters

A group of approximately thirty landless families is located alongside Rosário. They belong to the MST ,The Landless Social Movement, and have settled on public land along the road since 2002 to wait for the government's decision to dispossess a farm located in the municipality to allow them to occupy it. However, the government's decision went against the MST and the families have been requested to leave the public land, which they occupy. Although they have been told to leave (in February, 2004), they are still there because they have no place to go.Although they seem to be very suspicious of strangers, there does not seem to be any hostility between them and the Rosário dwellers and there is a case of a Rosário *assentada* woman who found a partner among the MST settlers.

(iii) Campo Alegre

Campo Alegre occupies an area of 863 ha and is divided into eighty-five plots of land. It was initially planned to be occupied by eighty-five families. The plots vary slightly in size and the average size is seven hectares. The area is cut by the Ipojuca River and the *assentamento* is composed of clusters of houses or *agrovilas: Esmero, Sete Barracas, Caledeirão I and Angola Nov.*.

Although there was an Irrigation School in the *agrovila of Esmero* in 1989, there is not much irrigation in Campo Alegre as it lacks the necessary water resources. According to the local population, the area is favourable for irrigation, but there are only a few residents with land located near water sources who engage in it. Most irrigation that is conducted by Campo Alegre farmers is carried out on plots of land located in other areas, rented for this purpose. This practice is particularly prevalent during severe drought periods. From September 2003 to January 2004, Campo Alegre farmers were irrigating land located in neighbouring municipalities such as, Arcoverde and Venturosa.

Campo Alegre has benefited from investments in the form of grants, but the level of investment has been lower than at Rosário. The government constructed a community-based cheese factory and a manioc flour mill. The government also invested in electricity distribution in the catchment, but as the population is dispersed, only a part of the community has access to this service. The Campo Alegre residents do not have title to the land they occupy, but in order to build their livelihoods, they were encouraged to apply for loans to invest in infrastructure and animals. Like the residents of Rosário, they have had serious problems with repaying the loans and the majority of them have been unable to do so.

On the few farms that engage in cultivation the most important cultivated crops are manioc, corn and beans. The remaining Campo Alegre landholders are largely engaged in rearing livestock. The Campo Alegre residents appear to be poorer than those in Rosário. The *assentamento* suffers from the same economic instability as in Rosário: several landholders have sold their plots and have later returned to swell the ranks of the landless group. The population is more dispersed than in Rosário because the dwelling houses are grouped in several *agrovilas* and not in one village.

The boundaries of Campo Alegre are not well defined. Even the residents themselves do not have a clear idea of the boundaries. Campo Alegre is also home to several medium sized properties owned by Pesqueira people. Away from the water courses, the problems of water supply are very serious. There are few wells. Wells drilled into the fractured basement are low yielding and the water quality is poor. There is a desalination plant for one of the wells, but it does not work. The people of Campo Alegre depend in the main for their drinking water on the municipal authorities which deliver water to individual households in water trucks during drought periods. During normal periods, water supply is derived from local sources; mainly wells and rainfall harvesting.

Campo Alegre lacks a strong and solid social organisation and there are community factions. The local Association is in the hands of the better off and the president lives in Mutuca. According to the Campo Alegre residents, he does not identify with the problems of the *assentamento* and has no interest in solving them, as he is not affected by them.

The Campo Alegre residents have a contradictory relationship with the Xukurú population. While some residents get along well and intermarriages have occurred, others are very suspicious of the Xukurú, especially because the latter occupy a very important area from the point of view of the water resources of the region.

Campo Alegre is adjacent to Roçadinho, a village populated by former landless Peixe workers. Although the Peixe Industry owned the area in which Rocadinho is located, it did not become an *assentamento* but instead was sold to farmers from Pesqueira. The Roçadinho residents thus only occupy the village houses and the community is comprised of fifty families. According to Roçadinho and Campo Alegre residents the area did not become an *assentamento* because the local landowners were interested in buying the land and the former Peixe workers living on the land did not request indemnity against loss of the land when they found out that the industry was closing down. The Roçadinho population is very poor and there are virtually no water sources to supply their needs. In addition to a few small ponds, there is a reservoir located on Campo Alegre land which is utilised by the Roçadinho population. The reservoir dam was constructed with public funds and the owner of the

land on which it is situated signed a document stating that the water would be available to the Roçadinho residents.

Except for the areas occupied by Roçadinho and the Xukurú, most of the surrounding land is owned by local landowners.

(iv) Mutuca

Campo Alegre is geographically close to Mutuca and the population of both areas are well integrated despite the differences in land tenure structure and organisation. Mutuca District in Pesqueira has a population of 2 720 inhabitants. Most people in the Campo Alegre area relate socially and economically to the small market town of Mutuca. The study area is quite distinct from both Rosário and Campo Alegre as it is not an *assentamento*, and was never owned by the Peixe Industry. The area of Mutuca is larger than the other study areas and apart from several rural properties many of those who own land live in the small town. The area benefits from some irrigation, however, the basic economic activity is centred onrearing livestock (mainly cattle) and the commercialisation of dairy products. Owing to time limits during the inception phase, little work has been devoted to understanding the socio-development aspects of Mutuca. This is programmed into the beginning of Year 2 of the Project. The geographical area of Mutuca in which the groundwater dams are situated is not only located in the Municipality of Pesqueira but alsoin the Municipality of Belo Jardim.

4.4.5 The Social Dynamics of Life in the Study Areas

The social structures of the *assentamento* are heterogeneous. Some people are financially secure but the majority are poor. The *moradores*, the landless groups, are the poorest. Many of these families require support from government social programmes such as Hunger Zero. Owing to the absence of work opportunities in the area, these programmes are of great importance to the survival of these families. The elderly play a very important role and have a high standing at the community level. This is due, in part, to the fact that their retirement pensions contribute significantly to the incomes of the families. In times of severe droughts, the elderly become the main providers for the families, as their pensions are commonly the only reliable source of income available.

Lace making provides an important source of income, particularly during drought periods when unemployment is high and there is no income from agriculture. Women in Campo Alegre and Mutuca tend to be engaged in lace-making more frequently than those in Rosário. During drought periods, migration is still the main option to overcome difficulties. Men usually migrate to the large urban centres and leave their families in their homes. Most migrants return after climatic conditions have improved.

The elderly talk about the times when the Peixe industry was still operating. They say that those times were good: nearly everyone was gainfully employed. , However today they find themselves better off as the government provides many benefits, the most important of which is the retirement pension for rural workers.

Families vary considerably in size; although, the average is five members. This figure is difficult to confirm as there are many extended families including the parents and their married offspring. It is interesting to note that most single mothers remain with their parents while some leave the children with their parents and move to urban centres in search of domestic work to support the children.

Despite the difficult economic situation, the health of the population is generally good. The most common illnesses are diarrhoea amongst the young and high blood pressure amongst the elderly. The strong presence of the community health workers is largely responsible for an improvement in the health of the rural poor. The health workers are usually from the community and are well known to

everyone. They pay periodic visits to each family and check on the health of all family members rather than waiting for families to seek help when they are ill. This system is very effective and the health workers are well respected in the communities and have acquired a leadership role.

Education is another area that seems to have improved through the years, based on information gathered from the population. In the past, there were fewer schools and most of the population was illiterate. The impact of this still can be seen as the illiterate are mostly elderly. The younger members of the community are not only better educated, but are more interested in seeking solutions to the problems which affect their daily lives. It is evident that those who are most interested in pursuing further studies face severe difficulties in accomplishing this as they cannot afford to live in Recife to attend University. It is interesting to note that although some educated young people still have the desire to migrate to the large urban centres in southern Brazil, many express an interest in remaining in the region and contributing to its development. Nevertheless, they complain about the lack of work opportunities, which makes it hard or even impossible for them to contribute to development.

The group composed of health workers, teachers, catechists and the educated young play a very important role in the communities. They not only have more formal knowledge, but they also occupy leadership positions and can be important agents of change. The younger community members play an important role in the sense that they are eager to learn and to exchange knowledge. They can contribute effectively to the sustainability of any action that is implemented to improve local living conditions.

4.4.6 Knowledge Gaps

A clear picture of the social dynamics and the conditions of the communities has emerged during the inception period. The functioning of the community in Mutuca is least well known but this was expected at this stage of the Project from the outset and will be resolved in the coming year, and as yet little is known about the Xukurú people. Therefore from a social development perspective little additional material is needed to support the next phase of work, although more information will be required about the organisation of agriculture and livestock rearing in the region. On the other hand, there are gaps in knowledge in relation to the physiographic information available to the Project team and work will be ongoing to gather together the necessary information in the next 18 months as the Project progresses. A serious deficiency, unrecognised in the formulation of the initial proposal, is the lack of any serious mapping for the region. The maps that are available are either at a scale of 1:100000 with limited resolution or larger scale but only showing a few specific features such as the road layouts and the town and village limits. This lack of spatial information has hampered the progress of the Project team in its evaluation of the Campo Alegre and Mutuca regions in particular. It will be essential for the completion of the conceptual characterisation of the hydrology of both regions that satellite imagery is obtained and used to define the topography, the land use, stream networks, land management and water control and water harvesting structures. Initial characterisation of the water resources functioning of each catchment has been carried out, but refinement of the knowledge embedded in these characterisations is still required to provide a basis for optimising groundwater use in each area. It will also provide a framework that can support the farm level monitoring of groundwater and surface water conditions.

Soils descriptions for Campo Alegre are relatively poor. Therefore, it is intended that a programme of soil characterisations will be carried out in collaboration with the farmers of the study area. The aim is to draw together the local knowledge and specialist knowledge through a joint programme of field investigations based on simplified data collection methods. This will provide a potentially very powerful tool for the integration of the Project team into the work of the community and in the education and training that will ultimately allow the communities to assess water resources availability.

5 Surveys and Workshops

5.1 Participative Socio-economic and Water Use Survey

5.1.1 The Methodology

Limited information was available on the socio-economic and political characteristics of the study areas. Participative socio-economic surveys were undertaken in two of the three study areas (Mimoso and Campo Alegre) to obtain a rapid understanding of the livelihood structure of the communities. A questionnaire was considered the most efficient method of obtaining the information.

The questionnaire survey was complemented through the use of in-depth interviews and life histories. The use of both quantitative as well as qualitative methods allowed for collection of data on a broad range of issues, involve the local population in the collection of data, and cover a large sample. To obtain an unbiased profile for the two study areas, the questionnaire survey was applied to the two *assentamentos* in Rosário and Campo Alegre, to the Mimoso Village and to the Roçadinho residents.

The questionnaire focused on information about individuals, family structure, social organisation, income, health, experience with migration and water related issues (general sources of water, drinking water, water for household use, water for animal use and water for irrigation). A draft version of the questionnaire was introduced to some members of community members, health workers and teachers to provide feedback on the contents of the questionnaire. The questionnaire was tested using respondents and, to avoid bias, these were did not participate in the final survey. The questionnaire forms are shown in Appendix C.

Six interviewers (three women and three men) from each of the two study areas were selected with assistance from the health workers. The criteria for selection of the interviewers were:

- be able to read and write;
- be from the community;
- be available to participate during this stage of the research as well as during others, including the monitoring and evaluation phases.

The total survey sample included 120 individuals, equally divided between men and women, and between the two study areas. A few questionnaires were applied to women and men from the Mimoso village and Roçadinho. Local health workers were consulted on the main characteristics of the population of the study areas. The health workers keep a record on all of the individuals residing in the areas, including age, gender, access to resources, health conditions, etc.

A one-day training of interviewers took place in Rosário. The introduction of the participants was done through a game on gender issues. Songs related to water were also played so that the participants could relax and feel comfortable. This was followed by a brief presentation of the Project and a discussion on participatory methodology, drawing attention to the important role of the local population. An explanation of the instruments used in the collection of data (questionnaire, semi-structured interviews and life histories) was given. The participants worked in groups of two, composed of a woman and a man to read and discuss the contents of the questionnaire. Each of the interviewers then applied the questionnaire to another to gain practical experience. Finally, the whole group engaged in a collective discussion of the questionnaire to express their opinions and to clarify any issues. The questionnaires were then distributed among the interviewers along with a list of the respondents so that the survey could start the following day.

Project team members monitored the work on a daily basis through meetings with the interviewers at each of the study areas to clarify issues and discuss any problems. The participation of local people in conducting the questionnaire was an important way of promoting their interest in the Project and their participation at other stages.

5.1.2 Summary of Findings

The detailed findings of the survey in relation to water issues are presented in Appendix C.

The questionnaire encompassed questions on a broad range of issues. Information about the personal background of the respondent, his/her family, experience on migration, participation in Association and awareness of its importance, type of tie to land, loans acquired, personal/family relationship to social programmes (Hunger Zero, Retirement, etc.), health conditions, employment situation, income and water (general sources, drinking water, water for household use, water for animal consumption, water for irrigation). From the collected information, it was possible not only to understand the current livelihood profile of the population, but to place it within a historical perspective. In addition to the questionnaire, data was collected through in-depth interviews and life histories and this enriched the information considerably. Information was collected from the general to the more detailed level, in other words, the same information about the population as a whole, was disaggregated by community, gender, sex, age as well as other variables.

The information acquired will be useful to the planning and implementation of the next Project phases. Furthermore, it can be said that the survey was an important vehicle for the development of appropriate methodological tools to be used in workshops, particularly in relation to water issues.

Figure 5.1 shows the distribution of population by sex, according to the length of residence in the area (shown in number of years). The information is relevant because the population tends to be very mobile and that the *assentamento* was formed during the period between 1992 and 1996.

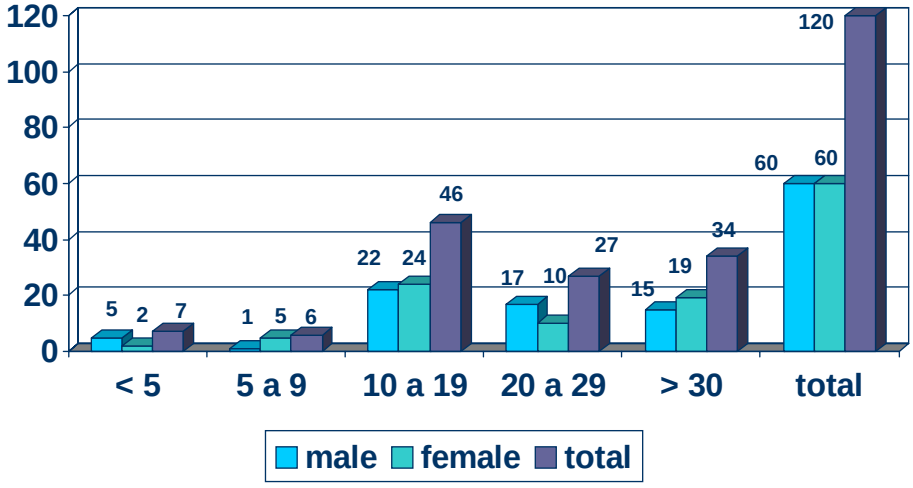


Figure 5.1: Distribution of Population by Sex and Period of Residency

Figure 5.2 shows the population's relationship to the land (the categories landless/*moradores, parceleiros and assentados.)*. The majority of the population who responded to the questionnaire is landless.

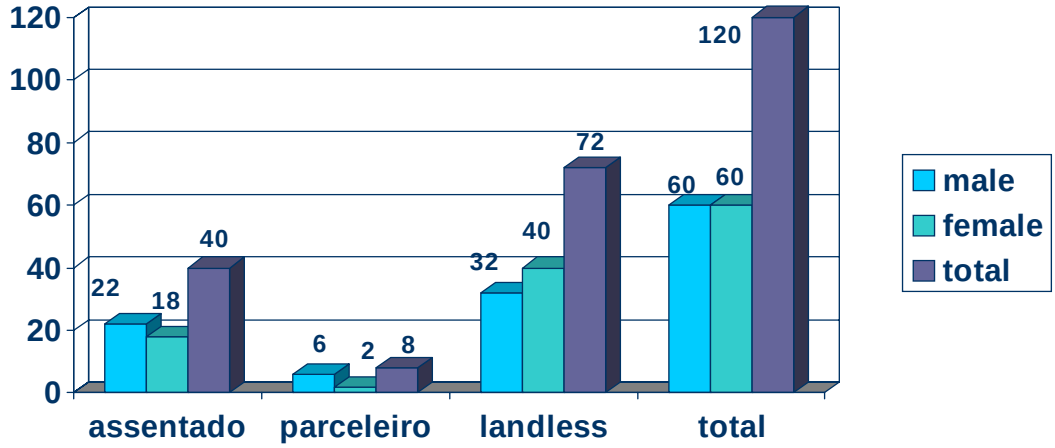
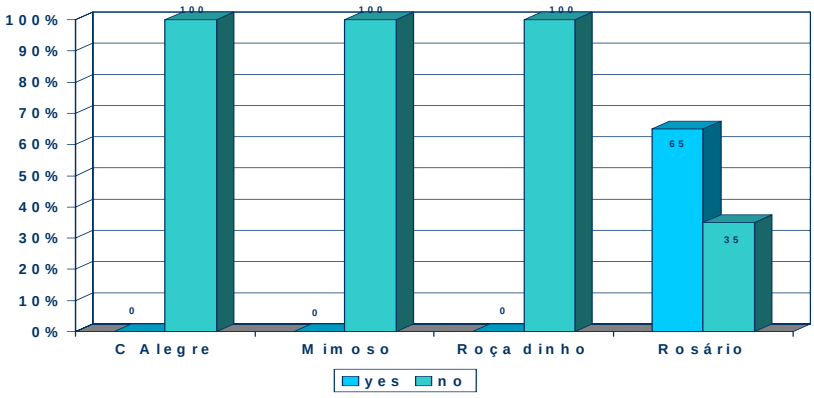


Figure 5.2: Distribution of Population by Sex and Land Ownership

The survey also shows that irrigation is most extensive in Rosário, as shown in Figure 5.3. Although not all of those from Rosário engage in irrigation, the community is the one who mostly benefit from it. The average size of the irrigated area in Rosário is 1.43 hectares. Although none of the respondents from Campo Alegre are involved in irrigation, it is known that limited irrigation in this area does occur.



- Average size of irrigated area in Rosário 1.43 hectares

Figure 5.3: Irrigation Practice in Surveyed Communities

The high price of energy is seen as a major problem for farmers who engage in irrigation in Rosário. 72% of the respondents stated that their monthly energy bill is higher than R$50, which is a large amount given the conditions in which these people live. This situation becomes worse at times of drought when groundwater water levels in the irrigation wells decline.

5.2 Introductory Workshops

Workshops were held during the Inception Phase in two of the study areas: Rosário and Campo Alegre. Socio-economic surveys had been carried out in both areas and information on important aspects of community life and people's needs were available prior to the workshops. The first workshop took place in Rosário on 5 March 2004. There were 56 participants from the local community covering a broad spectrum of backgrounds: women, men, youths, elderly, housewives,

farmers, school teachers as well as the local health worker. All community members were invited so that the workshop could involve such a heterogeneous group.

The second workshop took place in Campo Alegre on 23 March 2004. It had 65 participants with a range of backgrounds similar to the first workshop. Several individuals from Mutuca and Rosário also took part.

The workshops also included participation of representatives of the Municipal Government, including the mayor and the Secretaries of Agriculture and Education. The Municipal Government also provided logistical support: transportation and food.

The aim of both workshops was to introduce the Project to the community, to listen to the community and to understand the concerns of the community and to become aware of the tensions and issues that were uppermost in the minds of the community in relation to water and associated issues including health and welfare. In addition, basic ideas about the background to water resources management and community empowerment in the management of water were introduced. Further, field trips were undertaken to show how developments in irrigation technology could improve the productivity of irrigated areas and could reduce water consumption while maintaining yield. Salinisation issues were also addressed and methods for monitoring the climate – evaporation and rainfall and groundwater levels was also explained through introductions to the equipment currently operating on trial plots in Rosário.

The engagement of the participants in the workshops was excellent with a free and frank discussion taking place across a broad spectrum of issues. Many of the issues that justify the purpose of the Project were expressed by the community members and additional issues including the problems related to the domestic rainwater harvesting and water quality were identified.

Despite having the same format and agenda, the workshops were different in the sense that the level of dialogue, which the participants engaged in was deeper in Campo Alegre. This seemed to arise as a result of the participation of people from different communities. In fact this was one of the major lessons learned. Although it will be important for future workshops to be held in each of the communities so that the specifics of the areas can be discussed, workshops that provide opportunities for participation from different communities to exchange experiences and ideas will also be of great importance.

Fuller accounts of the two workshops are presented in Appendix D.

5.3 Well Survey

5.3.1 Well Survey- Mimoso Valley

In order to quantify groundwater use and to evaluate the importance of groundwater, a survey team undertook the collection of information for a representative sample of wells in the communities of Flexeira Velha, Mimoso, Climério and Nossa Senhora do Rosário farm in the Mimoso valley. The survey was carried out in February 2004 using survey questionnaire forms specifically designed for the Project. The forms are shown in Appendix E. Users of 32 wells were interviewed to characterise the wells according to the duration and time of use, the intensity of use, the purpose to which the water is put and the water quality.

The questionnaires focus on three types of information:

- General aspects: well construction., water levels, water quality, the range of water use, the beneficiaries, and alternative water sources;

- Irrigation aspects: irrigated crop types, crop areas; crop consumption; timing and duration of irrigation; irrigation method.
- Domestic and livestock consumption: Number of people which use the well, purposes of the domestic use, number and type of benefited animals.

Weather conditions had been unusual prior to the survey, with intensive rainfall occurring in the previous month. The total rainfall during January was about eight times the long-term monthly average, hence over 400 mm. This resulted in sever flooding and destruction of agricultural land and death of animals. Because of the excessive rainfall, groundwater was not the only available source of water. This caused some difficulties for the application of the questionnaires. For example, it was not possible to obtain information related to the irrigation method, irrigated area and time of irrigation for the present situation.

From the total of 32 investigated wells surveyed in the four aforementioned areas, seven were communal wells. In order to obtain more unbiased information, the questionnaire was applied more than once to different users for the communal wells.

The majority of the wells were constructed in the 1990's, when a programme of agricultural settlement was proposed by the state government of Pernambuco (Figure 5.4). The majority of wells (30) are large diameter Amazon type and are of variable depths as it is shown in Figure 5.5.

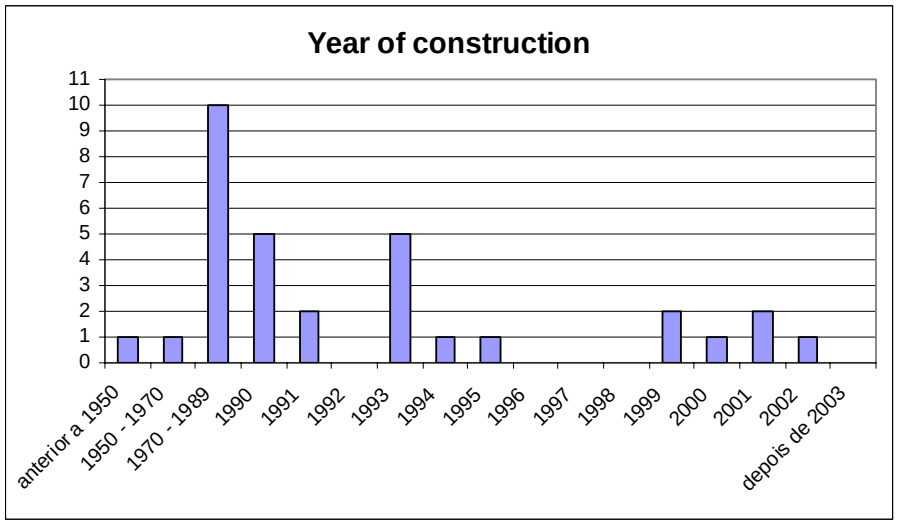


Figure 5.4: Distribution of the sample according to the year of construction.

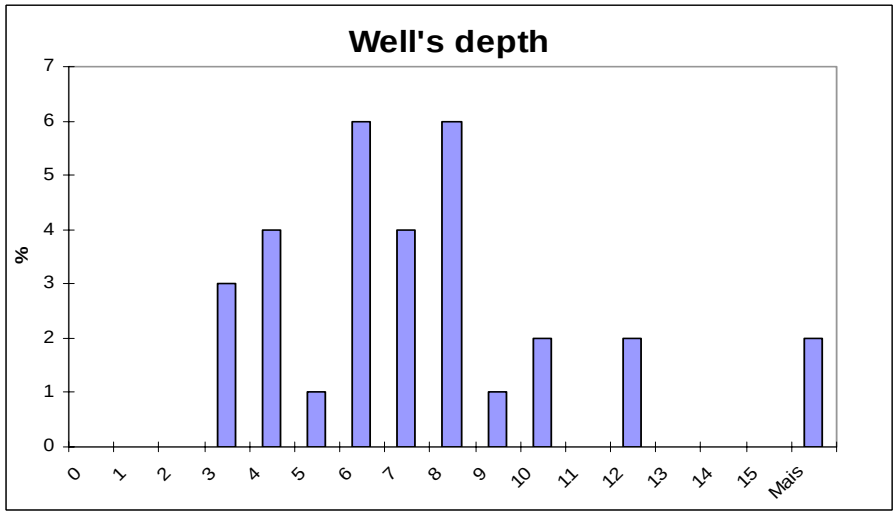


Figure 5.5: Distribution of the sample according to depth.

The electrical conductivity of the water from the well was measured at the time of the interviews, this in order to enhance the groundwater salinity information. It was observed that the electric conductivity of some wells had reduced significantly following the excessive rainfall during the previous month, while others indicated higher values (Figure 5.6). At the time of the interviews many wells were still submerged by water from neighbouring streams, or partially or total covered by sand brought with the flood.

An interesting fact arose when the users described the history of water quality, which showed neither increasing nor decreasing trends. The majority of people interviewed considered the water of good quality (Figure 5.7) and did not point to any type of restriction in use. 75% of groundwater was used for irrigation (Figure 5.8). Some wells are mainly used for selling water for the public supply of neighbouring cities (four in Flexeira Velha), although eventually they are used for domestic supply in the surrounding area.

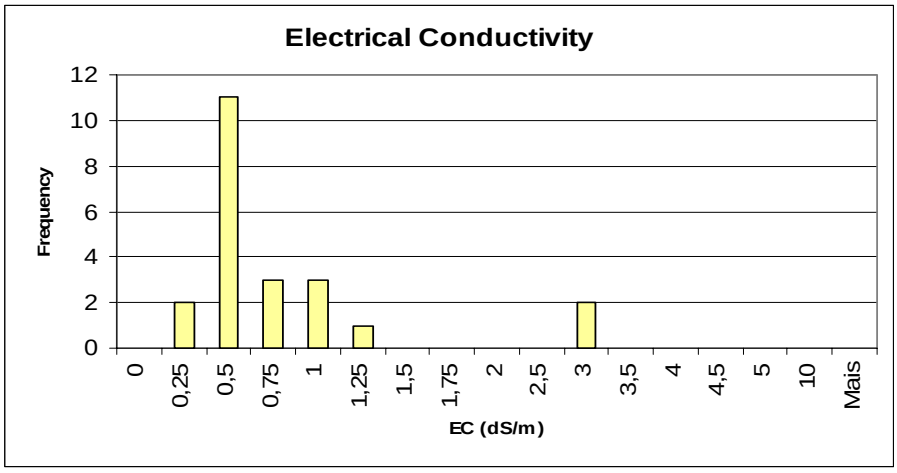


Figure 5.6: Electrical conductivity of water from the wells. February 2004.

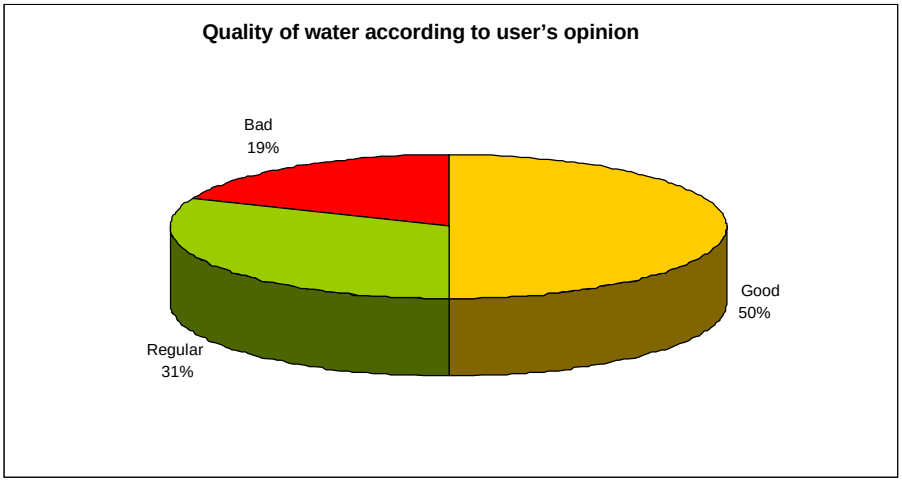


Figure 5.7: Quality of water according to user's opinion.

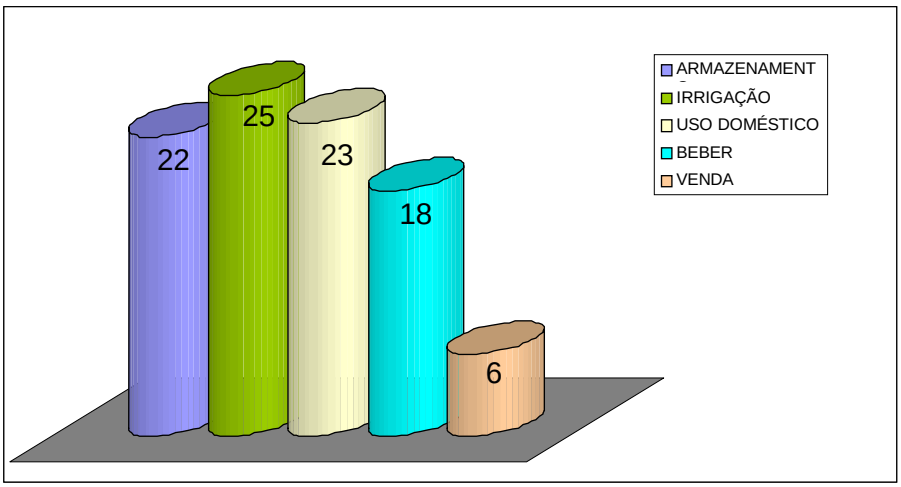


Figure 5.8: Number of wells and their final use.

In the community of Climério, where six wells were included in the survey, all the wells are used for small-scale irrigation and, in periods of drought, also for domestic use. Two wells are used for selling water. In Mimoso, a total of four wells have no restriction of use. In Nossa Senhora do Rosário Farm, with the higher concentration of the wells (18), 94% are used for irrigation, four of those are used exclusive for irrigation and seven wells are not normally used for domestic use. For the investigated area there is not a fixed rule for the use of groundwater, it depends on the sources available and the current needs. For example, even if water from a well is considered of bad quality, if there is no other source it is used even for drinking.

5.4 Stakeholder Analysis

5.4.1 Introduction

The stakeholder analysis has been based on the findings from the various surveys and workshops undertaken during the inception stage. The analysis is given in tabulated form in the following sections for different levels of stakeholder. The analysis involves an assessment of interests and positive and negative impacts of the Project as perceived by the stakeholders. For the primary stakeholders an analysis for the individual study areas is given. For this group of stakeholders there is also a distinction between women and men to reflect the often clear differences in perception between the gender groups. The list of stakeholders is not complete. Particularly those classed as secondary stakeholders need inclusion of the state institutions involved with water management and legislation.

The analysis of the primary stakeholders clearly indicates the difference in interest in water between women and men. For women in both the assentados/parceleiros and moradores sub-groups, the main priority is easy access to domestic water and good water quality. The men from the assentados/parceleiros sub-group, on the other hand, are interested in the use of groundwater for use in irrigation and the resulting increase in income, while those from the moradores sub-group (who do not own land) include guaranteed water for household use and animals as a main interest.

It is also interesting to see the interest of the Xukurú Indians in creating better links with the neighbouring communities.

5.4.2 Primary Stakeholders

	Stakeholder		Interests	Positive Impacts	Possible Negative Impacts
1	**Rosário**				
	Assentados/ Parceleiros	Women	Easy access to drinking water; Use of good quality water; Improve lifestyle; Assure conditions to remain in their land.	Saving time used to collect water; Improve the family quality of life; Become aware of the importance of political mobilisation for gender equity and sustainable livelihood; Becoming empowered through active participation in Project activities.	Could be the losers if irrigation is not balanced by drinking water training; Lack of full participation in Project activities will hinder women from benefiting.
		Men	Irrigation; Improve profit through commercialisation of crops; Manage the environment properly to avoid the degradation of their land and to stop out-migrating.	Increased profit; Reduce water waste in irrigation; Acknowledging the importance of political mobilisation through the local Associations; Extended knowledge over sustainable farming methods; Becoming empowered through their participation in Project activities and decision-making; Decrease of out-migration.	Only better off have access to irrigation/loans etc; If participatory methodology is not properly utilised by members of TE team, lack of accounting for local knowledge will lead to lack of interest and failure of the Project.
	Moradores	Women	Easy access to drinking water; Use of good quality water; Improve lifestyle and reduce their poverty.	Saving time used to collect water; Improve the family quality of life; Become aware of the importance of political mobilisation through Association.	Could be the losers if irrigation is not balanced by drinking water training; If they do not take part in training workshops due to unavailability and/or lack of interest, they may not see the benefits of this research.

	Stakeholder		Interests	Positive Impacts	Possible Negative Impacts
		Men	Guarantee water for household and animal use; Find a more stable source of income in water is available to *assentados* who irrigate; Have access to work in order to stop out-migrating; Reduce their poverty.	The creation of jobs; Acquisition of expertise on irrigation during training workshops which will lead to better chances of finding jobs; Rise in self-esteem and becoming empowered through participation in Project activities.	Cannot take advantage if they lack control over resources; If they do not take part in training workshops due to unavailability and/or lack of interest, they may not see the benefits of this research.
2	**Mimoso village residents**	Women	Despite being indirectly related to the Project, they might become enthusiastic by seeing the experiences acquired by the beneficiary communities.		
		Men		Develop interest in adopting knowledge over sustainable farming methods by seeing positive impact on beneficiary communities.	
3	**Other areas in the Mimoso Valley** (Fleixeira Velha, Climério etc.)	Women	Despite being indirectly related to the Project, they might become enthusiastic by seeing the experiences acquired by the beneficiary communities.		
4	**Campo Alegre *assentamento***				
	Assentados/Parceleiros	Women	Easy access to drinking water; Use of good quality water.	Saving time used to collect water; Improve the family quality of life.	Could be the losers if irrigation is not balanced by drinking water training.

	Stakeholder		Interests	Positive Impacts	Possible Negative Impacts
		Men	Irrigation; Improve profit through commercialisation of crops; Being exposed to the reality of the other study areas will enrich their experience and enthusiasm.	Increased profit; Reduce water waste in irrigation.	Only better off may have access to irrigation/loans etc.
	Moradores	Women	Easy access to drinking water; Use of good quality water.	Improves family quality of life.	Could be the losers if irrigation is not balanced by drinking water training. .
		Men	Guarantee water for household use Saving time used to collect water	They have no land to irrigate - but there might be more jobs available.	Cannot take advantage if they lack control over resources.
5	**Residents of neighbouring villages to Campo Alegre**	Women	Despite being indirectly related to the Project, they might become enthusiastic by seeing the experiences acquired by the beneficiary communities.		
6	**Xukurú**	Women	Easy access to drinking water; Use of good quality water; Become closer to non-Xukurú population.	Show the non-indians that the Xukurú are willing to allow them access to water resources in the reservation.	Increase in conflict over water resources between Indians and non-indians if permission to use water is not given. .
		Men	Easy access to drinking water Use of good quality water; Become closer to non-Xukurú population.	Show the non-indians that the Xukurú are willing to allow them access to water resources in the reservation.	Increase in conflict over water resources between Indians and non-indians if permission to use water is not given.
7	**Mutuca**	Women	Easy access to drinking water; Use of good quality water.	Saving time used to collect water Improve the family quality of life.	Could be the losers if irrigation is not balanced by drinking water training. .

	Stakeholder		Interests	Positive Impacts	Possible Negative Impacts
		Men	Irrigation; Improve profit through commercialisation of crops.	Increased profit; Reduce water waste in irrigation.	Only better off have access to irrigation/loans etc.
8	**Landless (MST)**		They are indirectly related to the Project and thus may not have any specific interest.		

5.4.3 Secondary Stakeholders

	Stakeholder	Interests	Positive Impacts	Negative Impacts
1	**Farmers Associations**	Utilize the Project to strengthen the Associations´ organisation.	Information acquired through the Project may help get projects.	May not benefit as a result of poor organisation and lack of commitment of members.
2	**Municipal government**	Take advantage from the Project by showing its ties to the Municipal Govt. especially in election years such as this one.	An improvement in the quality of life of the population in regards to aspects related to water.	The population may be asking the local Govt. for benefits they thought they would be getting from the Project.
3	**NGOs and Church**	Expand their experience by collaborating in irrigation, which is not one of CEDAPP's current priorities; Contribute to the reduction of poverty in the study areas.	Exchange experience with Project team members; Contribute to the exchange of experience through exchange visits between Project and CEDAPP communities.	
4	**UFPE**	Expand their scientific experiments in the sites; Through research findings, support the improvement of the quality of life of the population; Strengthen links between the rural poor and local government; Influence policy making devoted to	Exchange of knowledge and experience with UK scholars; Partnership building with UK Institutions.	

	Stakeholder	Interests	Positive Impacts	Negative Impacts
		programme.		
5	**UFRPE**	Expand their scientific experiments in the sites; Through research findings, support the improvement of the quality of life of the population; Strengthen links between the rural poor and local government; Influence policy making devoted to programme.	Exchange of knowledge and experience with UK scholars; Partnership building with UK Institutions.	
6	**FUNDAJ**	Through research findings, support the improvement of the quality of life of the population; Strengthen links between the rural poor and local government; Influence policy making devoted to programme.	Exchange of knowledge and experience with UK scholars; Partnership building with UK Institutions.	
7	**U. of Birmingham**	Expand their scientific experiments in the sites; Through research findings, support the improvement of the quality of life of the population; Influence policy making devoted to programme; Educational links with the Rural University.	Exchange of knowledge and experience with UK scholars; Partnership building with Brazilian Institutions.	
8	**Post graduate students**	Acquire knowledge by being exposed to a different social reality.		

5.4.4 Tertiary Stakeholders

	Stakeholder	Interests	Positive Impacts	Negative Impacts
1	**Mott MacDonald**	Partnership building with Brazilian Institutions concerning knowledge exchange and technology transfer.	Extending the experience in integrated and participative approaches to sustainable water resources and environmental management.	
2	**DFID**	Contribute for an improvement in the availability of water for sustainable food production and rural development; Poverty alleviation for the poorest of society; Strengthen partnership with Brazilian Government.	Achievement of the goals of poverty alleviation and promotion of adequate and sustainable water use	

6 Publicity and Public Relations

6.1 Project Dissemination

6.1.1 Introduction

Dissemination of knowledge and Project findings is a main component of the implementation stage. Most of the knowledge transfer to the local communities will be through the workshops which are planned for the second year of the Project. Knowledge transfer to local participants in monitoring and field investigations will also occur during the implementation stage. There will be an evolving and gradual transfer of monitoring capability of and responsibility for monitoring from Project team members to local participants.

A Project web site has been designed and will allow for information to be stored on Project development and findings. It will allow for more effective communication and exchange of information amongst the Project team members. It will also allow the external stakeholders and interest groups within the wider research community to learn about the Project and its findings and also participate in the wider discussion on sustainable resource management.

6.1.2 Project Web Site

(i) Aim and Objectives

The website has three main aims

1. To provide a window for the world to observe the development and outputs of the Project.

2. To provide a portal for information exchange between the various members of the Project team

3. To allow the progress of the Project to be monitored by all members of the team and to highlight areas where additional (or even reduced effort) is warranted.

To achieve the 3 aims the development of the web site will address six main objectives. These are:

1. To present the Project – its aims, objectives, approach and methods

2. To present the members of the Project team and to provide links to the respective member web sites, including e-mail contact addresses to allow external individuals or bodies to provide commentary to the team.

3. To provide an area for upload and down load of reports, data sets, images, artwork and map-work for use by the Project team. (Sensitive material should only be accessible by password access and only by Project members. Copyright notices will be included with specific materials.)

4. To present the Log Frame and the activity charts for the Project and to provide up-to-date information on the progress of the various activities.

5. To provide a notice board for requests for information from the Project team members and responses to the requests. This will be necessary to help build the links between the Social Development (SD) and the Technical Evaluation (TE) members.

6. To provide information on related resources on the Web that is relevant to the work of the team.

The web site has been built at Birmingham University and can be managed by staff at Birmingham University for the benefit of the Project throughout the duration of the Project period and for a suitable period (probably not less than one year beyond the end of the Project). An alternative would be to load the site onto the UFRPE or UFPE web servers. Either alternative could be adopted with little difference in development and testing time.

(ii) Architecture

The site uses a standard 3-frame windows template: a navigation panel; a header panel and a content panel. The navigation will be context driven. Effectively, the location presented in the content panel defines that part of the navigation menu that will be observable within the navigation panel. A rough outline of the total navigation menu is shown in Appendix F as an indication of the size of web site that is envisaged for the Project.

[Format – indentation determines level in page hierarchy….]

⇒ Top Page – Project Title
⇒ Project Description
  ⇒ Methods
    ⇒ Technical Evaluation
    ⇒ Social Development
    ⇒ Integration
  ⇒ Areas
    ⇒ The Region
      ⇒ Area 1 - Mimoso
      ⇒ Area 2 - Campo Alegre
      ⇒ Area 3 - Mutuca
  ⇒ Progress
    ⇒ Log Frame
    ⇒ Activity Progress Wave Front
  ⇒ Activities (Introduction)
    ⇒ Work Package 1: Development of Guidelines for sustainable resource management
      ⇒ Images
      ⇒ Documents
      ⇒ Maps
      ⇒ Data Sets
    ⇒ Work Package 2: Framework for community participation and education
      ⇒ Workshop and Seminar Programme
      ⇒ Images
      ⇒ Documents
    ⇒ Work Package 3: An operational strategy for integrated communications
      ⇒ Images
      ⇒ Documents
    ⇒ Work Package 4: Guidance on convenient and cost effective monitoring and intervention strategies.

- ⇒ Images
- ⇒ Documents
- ⇒ Maps
- ⇒ Data Sets

⇒ Upload/Down Load Area
⇒ database: Image Files
⇒ database: Document Files
⇒ database: Map Files
⇒ database: Data Files

⇒ Question and Reply Database
⇒ Question Data Base
⇒ Add Question

⇒ Staff Profiles

⇒ Related Resources

7 Summary of Findings and Key Issues

7.1 Team Building

The Project team comprises specialists form distinctly different professional and cultural backgrounds. Both professional and cultural differences have influenced the approach to the Project and have on occasions led to misunderstanding and tension. For the technical specialists the challenge is to move away from the traditional technical approach to projects, such as those conducted by the two universities in Brazil in the past. These projects related to small-scale irrigation trials and associated detailed monitoring. They included very limited involvement of local people and were largely top-down approaches to development.

On the other hand the social development specialists have generally only limited appreciation for pure technical issues. It has become quite clear during the inception stage that close collaboration between the technical and social development sub-teams is a pre-requisite for a successful outcome of the Project. Team building is therefore a very important component of the Project and this requires constant reminder of the team members of firstly the goal, purpose and outputs of the Project and, secondly, that working in isolation will not contribute to Project success and that communication is essential.

The nature of the Project is such that the social development aspects play a most important role. To some extent the technical aspects of the Project are sub-ordinate to the social development aspects. It is very important therefore that all technical activities relate closely to social development. Although pure technical aspects will be addressed during the Project, the majority of technical activity should take place in the overlap area between the technical (TE) and social development (SD) components of the Project. Reference is made to the matrix given in the Project proposal and shown separately in Table 7.1.

The matrix quite clearly demonstrates that the technical aspects are, to a large extent, reliant on local community participation and involvement and therefore closely integrate with the SD components. In fact the two components (TE and SD) can not be separated at any stage of the Project.

The emphasis of the TE components should be on the bottom-up approach, with many of the activities ‘led’ by local participants. Although this may seem inefficient, it is of key importance that local knowledge is tapped and appreciated, particularly at the early stages of the Project. It is further very important to realise that the technical activities are **not** a continuation of those conducted prior to the start of the KaR Project.

Communication between the TE and SD teams should be continuous and requires appreciation for differences in perception, appreciation and approach to the various activities. Exchange of knowledge and experience and continuous discussion amongst the team members is of great importance to the successful outcome of the Project.

Team building has proven a slow and painstaking process, although movement is in the right direction.

Table 7.1: Integration of Social Development and Technical Components

		Technical Aspects			
		Collection and Analysis of Information on Livelihoods, Hydrological and Hydrogeological Conditions	**Farm-level water use assessments and water use methods**	**Appraisal of options for monitoring methods**	**Determination of adverse condition indicators and associated uncertainties**
Socio-economic Aspects	**Establishing communication networks**	Integrate existing data held by the regional agencies and examine working relationships	Engage farming communities in discussions about alternative water use methods and outcomes	Undertake local assessments of data collection and assimilation methods	Invite participation in open consultations to determine the likely response to sustainability options
	Stakeholder analysis and engagement	i. Develop understanding of social and livelihood strategies and likely impacts ii. Explore knowledge levels within communities and interests in resource management	Review the processes by which individuals within the community function to determine water use and the level of influence/interaction between individuals	Examine the potential for take up of different options for community level water management and the maintenance of protocols and techniques	Review sensitivity of stakeholders to water conservation strategies and production failure minimisation strategies
	Skills training in community level water management	Demonstrate through practical applications how water balances are affected by individual decisions	Address with the communities the best approaches to managing the water resource and the best approaches to decision making	Design and implement monitoring strategies and train farmers and other users in water assessment methods	Prepare training programmes to relate monitoring data to stress level indicators and on to farm, community, region and state interventions.
	Creation and dissemination of information materials	Prepare summary descriptions of each pilot area and preliminary assessments of transferability of concepts to other areas	Formulate materials to indicate the production/water consumption ratios for different farm level cropping methods	Prepare operational manuals and other visual aids for monitoring water resource stress	Prepare outputs on stress indicators to indicate severity levels and the initiation of procedures at farm, community, region and state levels

7.2 Project Contribution to Poverty Alleviation

The Project proposal (Section 3.2.6) described the positive and negative impacts that may arise from Project implementation. These are repeated in the following in italics. The findings from the inception stage have not led to any significant revision to the contents of this section in the proposal. For clarity, the impacts are listed and comments related to the inception stage findings are included.

Environmental – positive impacts

- *With improved irrigation security there will be a reduced need to carry out illegal tree felling and charcoal production to augment family incomes.*
- *Similarly, there will be an ability to raise livestock off the crop wastes and reduce uncontrolled grazing thereby improving catchment management.*
- *Reduction in soil salinisation via the correct irrigation methods.*
- *Possible reduction in spread of desertification.*
- *Allowing recharge of aquifers for other uses.*

Project implementation will focus on land management issues and the potential or rainwater harvesting, thus improving the retention of water within the upper soil horizons. This will in particular benefit the rain fed agriculture, which for most farmers constitutes a main source of income.

Environmental – negative impacts

- *Possible destruction of native vegetation as a result of more intensive agriculture.*
- *Groundwater quality deterioration, particularly in relation to drinking water quality, due to use of fertilisers and pesticides.*

Within the study areas, native vegetation has more or less disappeared. There is hence less concern about the negative impact of more intensive agriculture on native vegetation.

The potential impact on groundwater quality remains.

Socio-economic – positive impacts

- *Improved livelihoods and a reduction in poverty*
- *Increased farm stability over the medium to long term.*
- *Increased rural populations.*
- *Expansion of rural areas beyond those previously exploited.*
- *Improved infrastructure.*
- *Encourage rights and responsibilities concerning water use.*

- *Strengthen local community groups, particularly farmers associations/ growth of social capital.*
- *Capacity building skills, bought about by newfound abilities to create positive change meaning future problems can be solved using the approaches already in place.*
- *Increased self-esteem.*
- *Greater economic outputs/ increased productivity of local community, leading to job creation and better standard of living.*
- *Extended knowledge of sustainable farming methods.*

There has been no indication from the inception stage findings that the positive impacts cannot be achieved. Risks obviously remain and these relate largely to the ability of communities to cooperate and participate in water and land management, and also to the willingness of state government to fulfil the aim of de-centralisation of water resources control. Additional positive impacts include an increased mutual understanding between the Xukurú and the 'white' population, and the improved sense of ownership of water resources.

Socio-economic – negative impacts

- *Possible causes of conflict, between farmers over access to resources.*
- *Tenant farmers may suffer if there is a reduction of mass land ownership. The poorest may not see the benefits of this research.*
- *There could be over optimism leading to debt potential, where there would be self-exploitation if a failure of long-term success occurs.*
- *The surrounding communities not targeted by the Project could feel excluded and this could generate conflict.*
- *Intra-household factors will have to be analysed carefully to mitigate potentially adverse impacts on, e.g. gender equity and child welfare arising from increases in the production of cash crops.*

Conflicts in the use of the groundwater resource are already evident. The situation with regards to the usage of the resource is complicated with regards to the current legislation, which exempts shallow groundwater sources from the need of an abstraction licence.

Institutional – positive impacts

- *Strengthen links between the rural poor and local government*
- *Institutional/policy change to incorporate research findings*
- *Greater links with other stakeholders and NGO's, for example the State Extension Service (EBAPE) and the State Water Resource Secretary (SRH-PE).*(Note that EBAPE no longer exists)
- *Educational links with the Rural University.*
- *Influence policy making devoted to programme.*
- *Supports the Brazilian policy of devolution of responsibility of water resources management to river basin committees and local water user associations (note PROAGA programme).*
- *Supports federal law which stipulates that, during water shortages, priority should be given to human consumption and watering of animals.*

Risks are related to the willingness of state government to fulfil the promises that are inscribed in the National Water Policy.

Institutional – negative impacts

- *None foreseen*
- *Institutional laziness could occur if the Project is seen as successful with just foreign input.*

Changing in local government may also have implications on the longer-term viability of community organisation.

7.3 Science for Development

Scientific knowledge for development and advancement has come under a great deal of scrutiny in recent years as scientific evidence presented to inform government actions and to motivate changes to working practices has been shown to be potentially flawed, bedevilled by controversy and conflict and subject to change as knowledge increases. As with all projects concerning the environment, the Project has to use scientific principles and scientific evidence to inform the development process. It is therefore appropriate in this inception report to reflect on the approaches that can be used to harness science in the pursuit of poverty alleviation and livelihood development and to explore the degree to which science can be introduced to and pursued by the population in a manner that can be assimilated and exploited readily by all sections of the community.

To do this, some thoughts are first presented on the evolving state of Science in Society and its value. Second, some ideas concerning the role of science in the Project are explored.

7.3.1 Science in Society

The view of science as an unbiased provider of necessary facts for policy makers to select and interpret does not resemble the actual scientific process. Science is not free of judgements and power bargaining processes (O'Riordan, 2000). Instead, it is argued that the scientific endeavour is socially constructed by a variety of norms, networks of bias and expectations (Knorr-Cetina, 1981). Berkhout *et al*., (2003:7) assert that 'the capacity of scientific advice to provide unambiguous analysis and recommend effective action has been challenged by evidence of the uncertainties and indeterminacies that pervade both analysis and action'.

Not only has the scientific process presented an obstacle for sound science-policy arrangements, but the complexity of social and environmental dilemmas to be addressed has also grown within which science is needed. This high degree of complexity and uncertainty creates difficulties in framing trade-offs, in specifying legitimate and fair policy actions, and in development of a broad understanding of environmental problems and their contexts (Adger et al., 2003:1096). O'Riordan (2000) argues that the acknowledgement of uncertainty in the face of complexity requires a transformation of science, and its relation to the policy-making process. It requires a form of science that is 'deliberative, inclusive, participatory, revelatory and designed to minimise losers' (2000:9). This emerging form of science, termed 'civic science or sustainability science' recognises that groups in society have to be involved if more comprehensive policy decisions are to be made (Lee, 1993:161; Levin, 1993).

The ways in which science for policy making as a process is currently changing may be described as 'science by partnership' rather then as 'science by intervention' (O'Riordan, 2000:20). While both are necessary components of the scientific endeavour, science by partnership recognizes that it is no longer independent, but a partner rather than an analyser. Instead of adopting a more authoritative

process, science by partnership recognizes value in sharing and listening, or in thinking through and with others. Munton (2003:130) summarizes the above-mentioned points by stressing that:

> *'the incertitude associated with many environmental issues demands that the widest possible range of knowledge be brought to bear on their management; that the complexity and breadth of consequence of environmental problems requires integrated approaches to their solutions, cutting across the narrow confines of compartmentalized expert knowledge and the responsibilities of established institutions and organizations; and that the concerns of environmental justice speak loudly to the under-represented and even silent voices of current environmental discourses, including nature and future generations'.*

The implications of this transformation process in civic science are far reaching. It encourages more interactive and responsive partnerships between researchers and stakeholders. The objectives of the scientific process are seen as less informative, and more participatory. O'Riordan (2003:person. comm.) delineates three postulates for the practice of civic science:

- Establish a new foundation for civic consciousness based on respect, responsibility and revelation;
- Enable citizens, via visioning, imaging and education, to relate personally to both local and global issues; and,
- Establish effective skills, capacity building and trust at the community level by new forms of representative-participatory democracy.

The implications of more participatory and sustainable science also affect research design. In exploring new visions for addressing sustainability, McMichael *et al*., (2003:1919) asserts that 'the inability of key scientific disciplines to engage interactively is an obstacle to the actual attainment of sustainability'. This process of engagement, termed inter-disciplinarity, involves a combination of 'knowledge and feeling, of measurement and judgement, of information and ethics, of explanation and participation' (O'Riordan, 2000:15). As distinct from multi-disciplinarity, where the actual study design is agreed by practitioners beforehand, in inter-disciplinarity the research process is highly exploratory. In other words, the conceptual framework is constantly being reshaped by information gathered and actions undertaken, although a sense of direction and objectives are always maintained throughout the investigation. In this way, the framework is shaped by evidence and evidence is shaped by framework in a continuous feedback process. In more inter-disciplinary studies, stakeholders are viewed as validating the facts gathered, not just as mere research objects. Stakeholders inform, shape, and are co-responsible for the production of research findings and policy implications.

7.3.2 Science in the Project

The discussion in the preceding section on the new concepts for 'civic science' provides some clues about the approach to civic science for water management and this Project. It makes clear that effective and inclusive science depends on the approach taken when applying scientific methods within a local context and culture. to know what constitutes 'public interest' in issues related to water use and management in the Pesqueira/Belo Jardim region implies more dialogue between the Project researchers and the stakeholders than has historically taken place. Previous research on irrigation and groundwater use has been driven, largely historically, from a need to understand processes affecting the productivity of the system and its sustainability without assessing how far the knowledge can be translated into practical advice and without understanding the human elements that will influence the final outcome. Although the goal of the research was to improve people's lives, the approaches used have had only partial success. Future science must entail re-thinking the way that scientific knowledge is being used and transmitted for the purposes of developing capacity in Mutuca, Rosário and Campo Alegre.

The question then arises as to what is needed in terms of scientific endeavour within the current Project. A great deal of science has been carried out on irrigation practices world wide and a not inconsiderable amount of work has been carried out in two of the three study areas. The knowledge that exists has not yet been fully accessed by the local communities and therefore the essential next steps are: to 'show' through inclusive trials how some of the worthwhile ideas that have been previously tested can be used by the communities, to establish how the cultural and social contexts influence the uptake of new approaches; and, finally to determine the feedback loops that exist between the physical and social settings to determine the optimal dynamic approach for the community in terms of water use, distribution and conservation. Of course, basic physical sciences that determine some of the contributory mechanisms may need to be dealt with as isolated building blocks, but for the most part scientific advances that are considered necessary through the irrigation and recharge trials should be undertaken with the full support and active participation of the community. In the development of the activities for the next year of the project, this is seen as an essential requirement.

Academic research will be carried out alongside the Project and will inform the Project through the testing of new specific ideas about the structure of the catchments, about the hydrology in the catchments and the physical processes that govern water retention and water redistribution in the catchments. This knowledge will be disseminated through the Project but will also be disseminated as a direct consequence of the interaction between the academic researchers (notably the Masters and PhD students appointed to work in each area) and the members of the local community. Through skills training provided by the Project in the approaches and methods to be employed in gathering information from the communities and discussing ideas and concepts applied in the research and disseminating the results of the studies, it is expected that the Project can help the community to embrace 'civic science' through involvement and personal interest.

Methods such as geophysical surveying may never become commonplace tools of a typical landowner but landowners who can see the value of the results from using such tools in their day to day work may have a better chance of developing their livelihood than those who prefer to use tradition solely as the model for designing future actions and controlling water applications. Development is a dynamic process and dynamic ideas are needed to progress the process. The Project must aim to create the necessary dynamism in the community and also in its team members and researchers on which it relies for technical inputs.

8 Project Planning

8.1 Introduction

The inception stage of the Project focused largely on 'knowledge' gathering to support the implementation phase of the Project and its successful outcome. However, the knowledge so far obtained is incomplete and knowledge gathering will continue during the Project implementation stage. This will rely, in part, on applied research and demonstration activities, conducted by the staff of the Brazilian and UK universities through MSc and PhD projects, and increasingly through monitoring undertaken by the local communities. Thus, Project implementation integrates a component of continuous knowledge gathering.

The participation of the local communities in knowledge gathering will evolve throughout the implementation stage, but will develop most rapidly in the period from July 2004 to April 2005. Capacity building in knowledge gathering will involve the combined efforts of the technical and social development members of the Project team, through the training workshops.

The dissemination of themed messages is proposed for the implementation stage. The themes are closely related to the Project outputs defined in the Log Frame and are integrated into a whole that should lead to the sustainable management of groundwater resources. At all times, the approach will aim at the empowerment of the participants from the local communities with a view to drawing them into dialogue in which their own knowledge is expressed and analysed so that this knowledge can be sensitively complimented by the information that the project has to offer.

The four message themes are:

1. Water storage and use for domestic purposes
2. Water for farming, including irrigation
3. Land management for improved water harvesting and retention
4. Institutional and organisational aspects of groundwater management

The messages within the four themes will be progressively introduced through the workshops in the period from July 2004 to April 2005. The themes are to some extent interdependent and will not be considered in isolation. The interdependency will be highlighted when the themes are addressed and the different messages are discussed with the community participants. At the conclusion to the implementation period between July 2004 and April 2005 the four sets of messages will be drawn together as an integrated whole, that brings together the different issues and potential solutions, and that is understood to all.

8.2 Translating Knowledge into Practice

8.2.1 Collaborative Approach

Water use and well surveys were conducted and other information collected in the first eight months to enable to sketch a profile of the peoples and the study areas and their environs.

Development of the messages under each theme will be achieved through a collective process dependent on agreed, achievable targets and close collaboration between the SD and TE sub-teams. The approach is schematically illustrated in Figure 8.1. The inputs to the process by the local community are central to the approach and are linked to all components of the process. An advisory panel is to be established that will be comprised of a range of specialists and representatives from both local and state level. State level involvement is anticipated to include representatives covering both water resource planning and legislation.

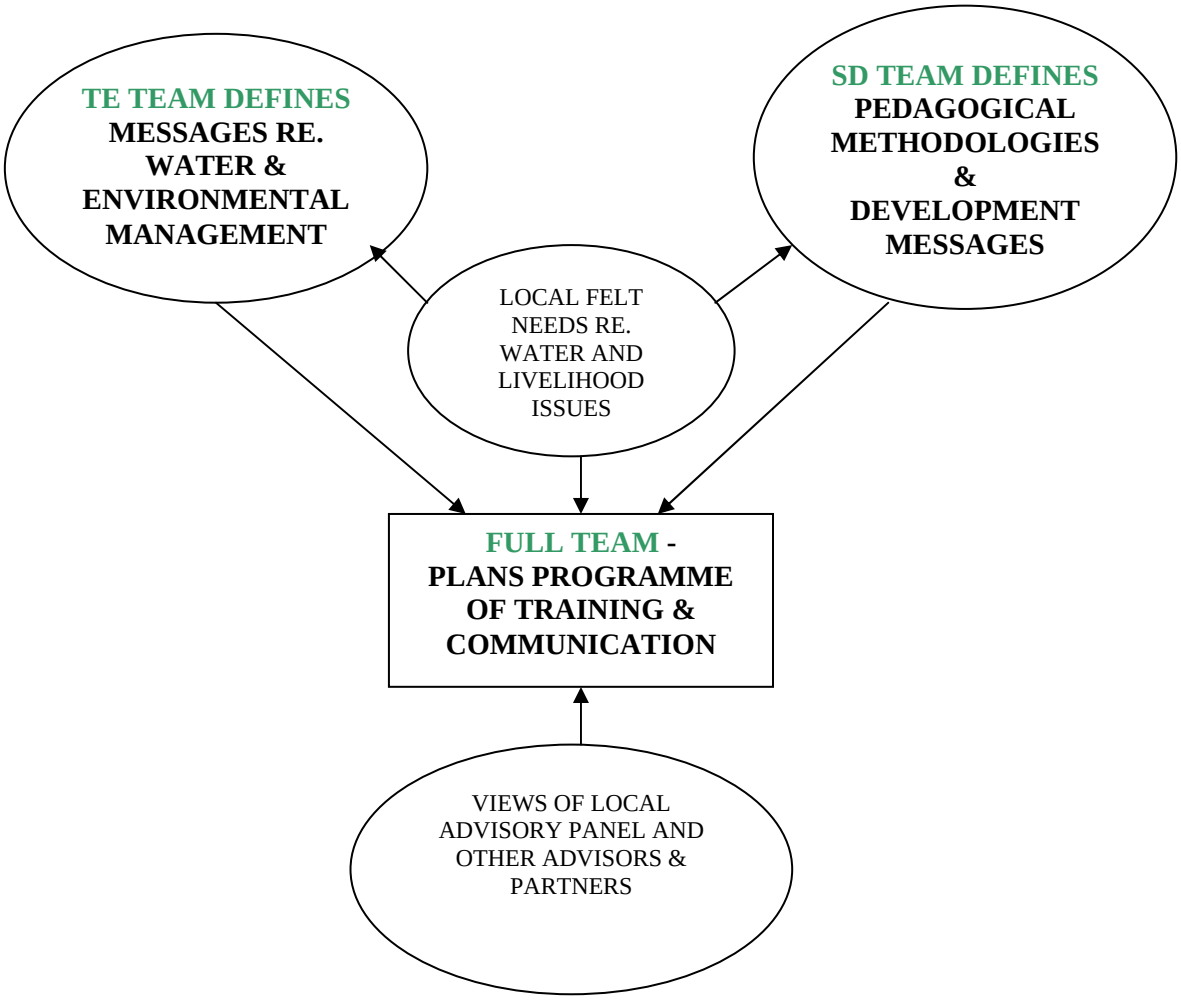


Figure 8.1: Schematic of Collaborative Approach

8.2.2 Consultation Advisory Group

The SD sub-team will consult specialists in rural communication and education. This is likely to involve specialists based in Recife and elsewhere who have worked in rural community development programmes in the areas of health, agriculture, environmental education and water resources planning and legislation. Local consultation in Pesqueira, on methodologies and strategies for programme delivery, will also be essential. It is envisaged that the local SD Consultant will consult with several rural school teachers and health workers. She would also examine methods used by CEDAPP (the local NGO) and transfer useful methodologies and strategies from previous experiences gained by the NGO into the "Framework for participation and education" and the "Operational strategy for integrated communications".

The Project can gain most from those who will share experience that values:

- Freirian school methodologies
- Process and 'empowerment' (in contrast to product and product delivery)
- Local knowledge, capacity and know-how
- Gender and education
- Environmental education

8.3 Theme 1 - Water Storage and Use for Domestic Purposes

Although this theme was not considered at Project conception, the inception stage has clearly identified the significance of domestic water use in the livelihoods of the communities in the rural areas. The livelihood surveys show that access to safe drinking water is the first priority for women. It has also become clear that local sources of safe drinking water are few and reliance is on water delivered by water truck. Rainwater harvesting is limited in the two study areas that have been surveyed, while local wells are mostly for multi-use and have no protection against external contamination.

Theme 1 will involve the creation of messages that are specific to domestic water use and water related health issues. The aim of these messages will be twofold; firstly, to build awareness of the use of water from different sources and the associated health risks, and secondly, to develop a two-way exchange of views on alternative solutions to the supply of safe water for domestic purposes. On the one hand, there needs to be a clear perception of the problems faced by community households, their understanding of water related health issues, and their suggestions regarding solutions. On the other hand, there is a need for the Project team to tap into the extensive world-wide experiences with safe water supply alternatives and technologies, and to expose the local communities to these.

This theme will also require clear messages that explore the relationship between health and education authorities at the municipal level and the local communities.

The issues that need to be addressed under this theme include the following:

- The livelihood surveys and the well inventories have provided an initial insight into the water and health issues related to water use for domestic purposes. Further analysis will be required to obtain a more precise understanding of the interests and concerns of community members, in particular women.
- The inter-community relationships and the relationships between municipal government and the communities require deeper understanding than exists at present.
- According to CEDAPP, sanitation is a major concern to the rural communities. The expression of this concern amongst the communities in the study areas needs to be better articulated.

8.4 Theme 2 – Water for Farming

This theme involves the creation of messages that are targeted specifically at agricultural production, water economy and exploitation.

The aim of these messages should be to expose the farmers in the areas to the limitations of the water resources in the area and to the possibility of gauging the likely success or failure of any crop by monitoring the quality and quantity of the resource. These messages should consider the local conditions at the farm level and present ideas that show how individual farmers can assess their own resource as well as how to maximise the use of their resource through improved methods of irrigation.

Theme 2 is linked to Themes 3 and 4.

Farming may be divided into two main categories; agriculture and livestock. Agriculture can be sub-divided into rain fed and irrigated agriculture. The issues that need to be addressed under this theme and related activities are presented below in relation to farming in general and to the different farming components in particular.

General:

- The identification of the extent of rain fed agriculture has been hampered by the lack of adequate mapping. Only topographic maps at a scale of 1:100 000 are available and local features cannot be adequately defined at this scale. The options for using satellite imagery will be explored to provide a better basis for mapping, and assist in the identification of land use and cropping patterns.
- During the inception stage it has not yet been feasible to begin to research the knowledge base of the communities. The activities conducted under this theme, and in fact under the other themes as well, will expose local knowledge and beliefs and will contribute to the evolving participation of local people.
- Groundwater level and salinity monitoring using an adequately designed monitoring system will help define groundwater availability within the study areas. The monitoring network has partly been identified through the well surveys that have been conducted in the Mimoso/Rosário and the Campo Alegre areas. A well survey in the Mutuca area is in progress. Where gaps in resource monitoring exist, additional monitoring points will be established under this theme. Local participation in monitoring will commence under this theme and will initially be supervised by Project staff, who will be trained within the Project in appropriate methodologies for this type of extension work. With time, the responsibility will move gradually to the local participant, who will be taught the techniques of water level and water salinity monitoring to the levels appropriate for the Project objectives. They will also be trained in the recording and dissemination of information.
- Training of local participants in the interpretation of the monitoring data will form an essential component of the training programme. Developing local understanding of the monitoring process and the value of the collected information for local farmers and rural families will contribute to the development of culturally acceptable guidelines for resource monitoring and utilisation.

Rain fed agriculture:

- A better understanding of the extent of rain fed agriculture is required. Why certain lands are used for rain fed agriculture needs to be investigated. The answer may relate to soil depth and soil properties that govern whether the soils retain sufficient quantities of soil moisture, to support crop growth through to maturity. In which case, more complete identification of appropriate soils or adjustment of inappropriate soils to render them useful can be envisaged.
- A walk-over survey will be carried out and reconnaissance soil auguring undertaken to enhance the understanding of soil depth and moisture holding properties. This survey will be initially undertaken jointly by a representative from URFPE and/or local trainers, and the local farmers. During the survey the farmers will be able to provide their understanding of the land, its soils and its suitability for growing rain-fed crops. Farmers will be taught to carry out the auguring and to interpret the soil samples taken. The farmers could then undertake these surveys independently so that a dense coverage of survey points is established over time.

- The success of the participatory approach to soil reconnaissance will depend on both the training of TE team members in participatory techniques and the knowledge exchange at the themed workshops.
- Land management and its effect of land productivity, although important in relation to rain fed agriculture, will not be addressed in detail within this theme but will be dealt with under Theme 3.
- There is as yet only limited understanding of the mechanisms of recharge to groundwater in rain fed areas, both those used for cultivation of rain fed crops and those used for grazing. There are indications from research work carried out by MSc students from Birmingham University that both surface and sub-soil conditions may severely limit the capacity of soils to transmit rainfall water to the underlying groundwater reservoir. This is an issue of some importance, because the limited capacity of soils to transmit water not only affects the moisture availability within the soil profile, but also the ability of the groundwater reservoir to transmit water to the adjacent alluvial valleys (by restricting recharge). The proposed reconnaissance soil investigations are expected to enhance the understanding of the surface runoff and recharge mechanisms. The enhancement of the capability for soils to absorb, retain and transmit water to the groundwater body will be addressed under Theme 3.

Irrigated Agriculture

- Further work is required to improve the understanding of historical and current irrigation practices within the three study areas. The following needs to be fully understood in order to provide the desirable baseline for activities under this theme for the three study areas:
  - The extent of the actual historical and current irrigation, and its relationship to climate conditions.
  - The extent of the potential area for irrigation, assessed by land suitability and water availability (in terms of quantity and quality).
  - The willingness of farmers to irrigate and the reasons for undertaking/not undertaking irrigation.
  - The market for produce and understand how the market works and alters.
  - The irrigation techniques used and approaches to scheduling in relation to water quantity and quality.
  - The use and ownership of irrigation equipment.
  - Crop yields and yield response to water application amounts.
  - Irrigation management in relation to disease and pest control, weeding and mulching and fertiliser use (chemical/organic)
- Farmer perspectives on irrigation have been partially explored through the livelihood survey but need to be explored further under this theme.
- An initial workshop will describe the Project purpose and explore areas where additional knowledge can be provided by the farmers directly.
- In addition, combined walkover surveys and interviews will be carried out with farmers to provide a more in-depth and personal profile of knowledge and opinion about irrigation. Farmers involved will include individuals who already practice irrigation, as well as those who do not practice irrigation yet have land suitable for irrigation.

- Irrigation experiments are conducted in the Campo Alegre and Mutuca areas. These experiments are carried out by URFPE, but so far do not involve local farmers in a full participatory manner. Future experiments and trials should be primarily held on demonstration plots where farmers learn about alternative irrigation methods and irrigation management sustainability and will be complimented by other teaching methods. The trials can demonstrate water saving options and the relationships between yield, net revenue and sustainability.
- The role and potential of the Pão de Açúcar reservoir for supply of surface water for irrigation to the Campo Alegre area will also be explored under this theme, in collaboration with the Xukurú and residents of Campo Alegre.

Livestock Farming

Livestock farming occurs in all three study areas and is dominant in the Campo Alegre and Mutuca areas. During the rainy season, rainfall water is harvested in small lakes and behind impoundments and is abstracted fromn surface water flows. When surface water is no longer available the farmers resort to groundwater abstracted from dug wells located within or adjacent to the stream beds. This water is often low quality (high salinity) and becomes worse during prolonged drought periods.

The livelihood surveys conducted on the Mimoso/Rosário and Campo Alegre areas to date include questions related to water use for animals but the number of questionnaires completed so far is not adequate to gauge the full extent of water use for cattle. A more complete understanding of the extent of livestock farming and the extent of groundwater use for this activity will be acquired under this theme.

8.5 Theme 3 – Land Management for Improved Water Harvesting and Retention

The processes of water transfer and surface runoff in the three study areas are not yet clearly understood and currently MSc students from Birmingham University are undertaking field trials to enhance this understanding in the Campo Alegre and Mutuca areas. It is not yet known how much farmers in the local community are aware of techniques for enhancing infiltration in to the soil profile. Further work will be undertaken by a PhD research student from the University of East Anglia.

Rainwater harvesting is practiced widely throughout the world and an overview of techniques that might be appropriately applicable to conditions in the study areas is available in the literature. The reconnaissance soil surveys undertaken under Theme 2 will provide the basic data for assessing rainwater harvesting options.

The concepts of rainwater harvesting and associated land management will be discussed at the planned workshops. Experimental trials could be implemented in response to feedback from the farmers on the available methods.

Guidelines on the application of rainwater harvesting for sustainable water management will be produced.

8.6 Theme 4 – Institutional and Organisational Aspects of Groundwater Management

This theme covers Federal and other programmes, gender and water, rights and responsibilities, conflict resolution, advocacy and effective/ democratic social organisation. Its function is to ensure that the Project work continues after Project completion. Thus the primary objective of Theme 4 is to

lay the foundations of a process with the stakeholders, which can help them to pursue valuable aspects of the programme beyond the Project period.

8.7 Planned Activities

8.7.1 Introduction

The planned activities for the period from July 2004 to April 2005, described in this section, relate largely to the themes described in the previous sections. . Activities for the final period of the Project, from May to December 2005, are presented in outline and will be reviewed at the Project interim stage in April 2005. Activities during 2005 will be specifically targeted on the Project outputs.

The activities are planned as integrated activities, with team members working in close collaboration. A main driver for the implementation phase is developing the two-way transfer of knowledge and building the capability of community members to undertake monitoring and resource management. Strengthening the links with Municipal and State institutions, the church and NGOs is also important. It will be necessary to try to obtain 'buy-in' to the Project goal from these institutions.

The knowledge review has already indicated that work carried out in the study areas in the past, particularly in relation to technical monitoring and irrigation trials, had a strong technical and experimental research bias with only limited involvement of the local population. Such work is important to the Project, particularly in relation to the assessment of groundwater resource availability, but in future it will be largely participative, with the aim of demonstrating techniques and procedures and providing local people with the ability and incentive to undertake data collection and interpretation with no or minimal supervision.

Technical components of the first three themes have been divided between three main strands: monitoring and field reconnaissance, assessment of groundwater and surface water resource availability and irrigation demonstration trials.

Section 8.7.2 describes the activities planned for each strand while Section 8.7.3 elaborates on the training aspects and knowledge transfer related to the technical inputs to the Project. Section 8.7.4 describes the social development activities related to dissemination and communication strategies.

Section 8.7.5 describes the Project team organisation and the management of the activities described in Sections 8.7.2 to 8.7.4.

8.7.2 Technical Aspects Related to the Groundwater Resources and their Utilisation

(i) Monitoring and Field Reconnaissance

All monitoring components described here are based on low technology approaches and can be easily undertaken by the local community. They include monitoring of:

- Groundwater levels and groundwater salinity.

  Groundwater levels need to be monitored on a regular basis, ideally twice per month but not less than monthly. Water levels can be measured relative to a fixed reference point on each of the monitoring wells and piezometers identified in each area and the data gathered will, over time, describe the pattern of changes in the volume of groundwater available within each area. Since groundwater levels are generally near ground surface, simple measuring devices (such as poppers) will suffice. Well water level measurements may be taken by

different individuals at each monitoring well or, depending on the wish of the community, by a single person who is responsible for all well water level measurements.

Groundwater electrical conductivity observations provide a simple measure of salinity but require a hand held meter. Thus, it is anticipated that monitoring of salinity will be undertaken by one individual from a community who is trained in the use and maintenance of the equipment. The measurement of salinity need not be as frequent as the measurement of groundwater levels: probably twice yearly will suffice.

- Water use.

  Monitoring of water use, with a breakdown for different modes of usage, requires regular updating of data by individual or groups of users associated with each well or surface water body. Data recording sheets will be produced for each major water supply source and the completion of the sheets will be established through local water user association. The association will collate the records and will monitor the effectiveness of the data gathering process. The Project will aim to involve both women and men in the monitoring activity to ensure that the different interests in the use of water are recognised in the monitoring results.

- Land use.

  The routine monitoring of land use will be preceded by an inventory of land potential for irrigation and rain fed agriculture. This inventory will be largely based on farmer knowledge, and the reconnaissance soil profiling programme. The monitoring of land use involves the recording of cultivated and pasture land area, the crops grown (including the reason for choice of crop), the cropping calendar, type of irrigation (if applicable) and source of water, application of fertilisers and pesticides, crop disease and crop yield, and the availability and mechanisms for transporting and marketing crops.

- Rainfall and evaporation.

  The UFRPE and UFPE have been instrumental in the design and use of low technology rainfall recorders and evaporation pans. Rainfall recorders will be installed at selected location within the study areas so that a better understanding of local-scale variability in rainfall will develop. The rain gauges can be monitored by local people after appropriate training. Evaporation is measured from evaporation pans and, given that evaporation is less spatially variable than rainfall, it is anticipated that only one will be needed in each study area.

- Reconnaissance soil profiling.

  Soil profiling undertaken by MSc students during June 2004 in the Campo Alegre study area has revealed that the soil profile is layered and that moisture holding properties of the layers is very variable. The thickness of the individual layers also appears to be spatially variable. It was observed that the upper soil horizon exhibits good moisture holding properties, while the underlying layers exhibit very poor moisture holding properties. It appears that the thickness of the upper horizon has a potentially dominant influence the successful cultivation of rainfed crops.

  Reconnaissance soil profiling will be undertaken to obtain a better understanding of the spatial distribution and composition of the main soil horizons. Soil profiling is relatively simple and involves the drilling of a small diameter auger hole to a depth of about one metre and the recording of the soil samples extracted from the hole. It is anticipated that local farmers will be able to undertake the profiling once appropriate training has been given.

(ii) Regional Resource Assessment

A lack of appropriate mapping has constrained severely the initial appraisal of the extent of the regional groundwater resource. An extensive local search for maps at an appropriately detailed scale proved unsuccessful and only maps at a 1:100 000 scale with 50m interval ground level contours are available. Geological and soil maps are available but only at a reconnaissance scale and are, therefore, also inappropriate for study area scale assessment. A better map base will be derived from satellite imagery.

Some of the MSc projects carried out by students from UFPE, URFPE and Birmingham University are aimed at initiating regional groundwater resource characterisation and the assessment of groundwater flow behaviour in the underdeveloped areas of Campo Alegre and Mutuca. Specific field investigations and monitoring are being undertaken by the students under the supervision of senior university staff. In the longer-term, however, the understanding of the resource will gradually improve through the information obtained from monitoring undertaken by the local communities. The MSc projects provide useful inputs to the Project and will continue through the remainder of the Project period.

(iii) Irrigation Demonstration Trials

Extensive irrigation trials have been conducted in the past by UFRPE as part of funded research programmes. These trials have resulted in knowledge that can usefully be incorporated in the knowledge base of the Project.

The introductory workshops held in two of the study areas have clearly demonstrated the interest of farmers in irrigation, as they see this as a way of improving their livelihoods. They expressed a very keen interest in the irrigation trials during the field visit undertaken during one of the workshops. Opinion, understanding and experience regarding irrigation varied significantly.

Irrigation demonstration trials are believed to be an excellent way of showing farmers different irrigation management methods and how these impact on water use and crop production. The trials will therefore be clearly focused on local farmers and will include elements of training and self learning. The training will include elements related to water and land use.

There will also be a more scientific element to the irrigation trials and this will be covered outside the Project through academic programmes involving MSc and PhD students from UFPE and UFRPE. The findings of these scientific studies will feed back to the Project.

(iv) Other Activities Related to the Themes

Additional activities that are specific to themes 1, 3 and 4 are identified here. All activities related to Theme 2 have been covered by the general approaches presented in the preceding sections.

Theme 1:

- The experience obtained from local-scale implementation of rainwater harvesting and sanitation systems (through CEDAPP and the World Bank funded one million cisterns programme) will be analysed in terms of technologies used and the impact on livelihoods.
- Through the Project workshops, local knowledge and opinion about water and health issues will extend the knowledge obtained from the livelihood surveys and stakeholder analyses. Surveys have to be conducted in the Mutuca study area.

- The technologies for rainwater harvesting and sanitation used in the Northeast and in different parts of the world will be evaluated in terms of technology and livelihood impact. Solutions used and their evaluation will be discussed with the communities in the workshops.
- The capacity for self-help within the communities, particularly in relation to construction of water sources and sanitation systems, will be evaluated.

Theme 3

- A detailed review of rainwater harvesting and land management techniques will be carried out, both in terms of practical application within the study areas, the Northeast of Brazil and the wider world, and in terms of the knowledge and understanding of such techniques amongst the study area communities.
- The potential benefits of the techniques will be discussed at the workshops planned under this theme.
- Where feasible, demonstration trials at a medium scale will be undertaken. The feasibility of these trials will depend on the willingness of the local communities to participate in such trials. The latter will depend on the feasibility of implementation of rainwater harvesting and land management techniques.

Theme 4

This is potentially one of the most challenging themes, since the achievement of the Project goal of long-term sustainable use of groundwater resources and poverty alleviation will depend on the support of the local institutions and their willingness to continue the activities after Project completion. Activities related to Theme 4 will be conducted during 2004/2005, although a much stronger focus on this theme will be given during the final stage of the Project in 2005. Activities of particular relevance include:

- Establishment of close links with relevant institutions and organisations and their active involvement with the Project (through the Project Advisory Group).
- Decentralisation of the management of groundwater resources and the control over its equitable utilisation will be put into practice. Ambiguities in the water rights issues need to be resolved to ensure equitable and fair use of groundwater. Extensive consultation with the relevant institutions (particularly SECTMA) is required to reach a clear commitment to the goal of decentralisation of resource management and the empowerment (in legal terms) of the local communities.
- The outline framework for institutional development requires preparation during 2004/05 and requires buy-in, not only from the local communities and their existing Farmer Association, but also from State and Municipal institutions. One of the challenges is to separate this framework from the local political sphere. The actual development of community institutions will be an activity for the final stage of the Project.

8.7.3 Training and Knowledge Transfer

(i) Training and Knowledge Exchange amongst Project Team Members

This involves training of junior Project staff in Project related disciplines and knowledge transfer across social science and technical disciplines. It also involves training in communication skills

relevant to effective knowledge exchange with the local communities. The objectives of this training are twofold: firstly, it will enhance mutual understanding between disciplines and, secondly will enable more successful exchange of knowledge between Project staff and community representatives, particularly those involved with monitoring.

Technical Project staff require training in participative techniques, attitudes and communication skills to work with rural people. Social development staff require an enhanced understanding of the technical issues described in sub-section (i) of Section 8.7.2. All staff need to have the opportunity to explore, together, the interface and relevance of their various professional disciplines to the project purpose.

The training and knowledge exchange will be undertaken during several workshops to be held in Recife. The first workshop is planned for July 2004. Subsequent workshops will be held at regular intervals during the implementation stage and will include evaluation of the practical application of techniques in the study areas and enhanced communication skills. The training will be participative and will include active participation of junior Project staff. Students from UFPE and UFRPE involved with technical field experiments, which are not directly related to the Project, will also be able to attend the workshops to gain experience in communication techniques. The workshops will be coordinated by Brazilian senior staff members of the Project, covering the social development and technical contributions.

(ii) Training of Local Trainers

Local trainers will be selected from rural teachers, health workers and others prepared to contribute to the Project. The local trainers will be involved in the workshops related to the various themes and will also communicate Project issues on a one-to-one basis with community members.

The training will be delivered in Pesqueira. The first training session will be in mid October 2004, after the municipal election. A second session is planned for early 2005.

(iii) Thematic Training and Consultative Workshops in the Study Areas

These are the training and consultative activities which would take place monthly from August 2004, following team preparation on the first of the four main programme themes and the consultation and Project team members training activities. In order to limit the number of workshop participants and to gain local loyalty and commitment to learning, the training workshops will be presented as training courses. Individuals who subscribe and/or who are nominated will be invited to attend workshops appropriate to their particular interests and will be given a certificate. Numbers will be limited to a maximum of 15 people per community/area per session, although some flexibility will be allowed. Every effort will be made to attract equal numbers of men and women where possible and to ensure that the group is as heterogeneous as possible.

The first course of workshops will last for nine months (August to April 2004/05) and will be evaluated at the end of this period. The course of workshops will involve participants from the three study areas and will be held in different communities as appropriate.

Assistance for the workshops will be requested from organisations involved with communication in the rural areas of the Pesqueira municipality (eg from CEDAPP or other institutions).

Information and training material will be prepared in advance of the workshop and this may include exhibition video material as deemed appropriate.

(iv) Team-building Training for Senior Project Staff

Senior project staff from the UK and Brazil require a high level of mutual understanding of project purpose and goals. From the onset of the project, it has been recognised that the key to success of this project is interdisciplinary collaboration at all levels of the project, and most particularly at senior level. Staff are from different professional backgrounds and have very different types of professional and experience. They have identified the need for the following types of training as a team:

- Agreeing project objectives and work strategies
- Inter-professional and international communication skills
- Low-level conflict resolution

Two training days are planned, each in Recife. They will be run and facilitated by an external professional with experience in this type of training for team building. The first will take place in November when UK staff are visiting. The second will take place on the first possible opportunity in 2005, possibly in March, when all senior team members can be together.

(v) Seminar in Recife

A seminar will be held in Recife (date as yet to be agreed) to present the interim findings of the Project to the stakeholders. The seminar will be attended by Project team members from Brazil and the UK.

8.7.4 Dissemination and Communication

The activities related to dissemination and communication are described below. Some of the activities require a more detailed formulation before a final decision on their inclusion in the Project is taken.

- A dissemination and communication strategy will be developed by October 2004. There will be extensively consultation with the Brazilian team members, the stakeholders and other advisors.
- An advisory group will be established including representatives from primary and secondary stakeholders. The Project team will consult on a range of issues initially on educational methodologies. The group will consist of a select number of rural school teachers, health agents and other local men and women as appropriate. Also included are representatives from the State-level regulatory authorities. It is not envisaged that this group will be a fixed group of people throughout the year. Individuals with particularly relevant experience may be invited to meetings to discuss their area of expertise if the need is identified.
- Education and communication materials will be prepared, which will reflect the content of each of the programme's four broad themes. Initially, in 2004/5, the materials produced will be in a simple format, possibly photocopied, and will, to some extent, be experimental. After the completion of each group of workshops on one broad theme, the course materials will be reviewed and revised. They will eventually be produced in a revised, updated and more robust form for use during the final phase of the Project in 2005 (and afterwards). The material will be appropriate for use by participants of the workshops (the rural people many of whom are scarcely literate and rural school students (up to 8th grade). Information sheets will be used either individually or as a full information/education pack.

- A local theatre group (Grupo Trampolim - or possibly a local clown) will be invited to present a short sketch illustrating the theme of each one of the training sessions described in Section 8.7.3 (iii). Once the plan for the training course is complete, the theatre group will be contracted to prepare their sketches - one for each of the monthly sessions. As soon as the material for the second thematic workshops is complete, they will be invited to prepare for those sessions and so on. The Project team will give a detailed brief to the group for each one of their sketches and will work with them to guide them in preparing for the performance.
- A poster to convey a profile of the Project and its principle message(s) will be prepared for use by all stakeholders, urban and rural, water end-users in the Project area, local government, local and regional NGOs, Church etc.
- A travelling exhibition will be prepared, comprising a display of the Project's photos, publications, graphic material, etc., designed to increase the Project's profile in and around Pesqueira. The exhibition will be displayed at public events in Pesqueira town whenever possible (official, educational, NGO, Church etc.) at the training courses and in neighbouring towns eg. Arcoverde, Alagoinha, Belo Jardim and others. Content of the exhibition will be decided by the Project team and the Advisory Group during October 2004.
- Visits of local community representatives to other projects (eg those initiated by CEDAPP and CAATINGA). Representatives from communities involved in those projects would be invited to attend workshops and seminars organised under the KaR Project.
- It is proposed to prepare an educational video about the Project - *a pilot project* about sustainable water management and environmental education. It is envisaged that the process of making the video will in itself, contribute to dialogue with water-users in the target areas as well as dialogue within the Project team. The content of the video would be include:
    - Water and environmental management messages (as agreed in the Project planning in the full team)
    - The process of the Project - seeing it through its first phase
    - Located in the Municipality of Pesqueira in the study areas, the video is about people and their water.

    The target public would involve local people, especially rural people, the primary stakeholders of the Project and rural schools.

    Given that the video would become an educational tool, it should be completed during 2004 so that it can be used in the programme during 2005.

8.7.5 Livelihood Survey in Mutuca Study Area

Sixty questionnaires will be carried out with assistance from six people who have already been trained. Each person will do ten questionnaires. The respondents will be 30 women and 30 men. Data will be analysed in IMPS but will hire someone to enter the data. The criteria for selection of the interviewees will be prepared by the social development sub-team. The interviewees will include *moradores* and small landholders with a variety of occupations.

Data regarding larger landholders including *fazendeiros* will be acquired through interviews.

Additional qualitative research based on interviews, visits and consultation with external informants, will also complete the social, economic and water-use profile of this area,

8.7.6 Xukurú

The social development sub-team will identify and recruit an appropriately qualified and experienced consultant to undertake the following work with the indigenous population:

- Provide a socio-economic, environmental and water-use/attitude briefing to the Project team for the Xukurú people.
- Advise the Project on all relevant aspects of work with the Xukurú.

8.7.7 Project Team Organisation and Management of Activities

An integrated participative planning approach will be adopted for the Project implementation stage as illustrated in Figure 8.1. The key players involve the Project team members, the local communities and the stakeholder representatives. The Project team comprises a social development (SD) and technical (TE) sub-team, with distinct primary responsibility for implementation of the Project messages. At no time, however, will any of the sub-teams work in isolation, particularly during the activities that involve participation of community representatives.

Within the technical sub-team the main responsibility for the sub-activities described in Section 8.7.2 is with UFPE (sub-activities 1 and 2) and UFRPE (sub-activities 2 and 3). For sub-activities, which involve knowledge transfer to community members, the field teams will comprise junior team members with both technical and social development skills working.

8.8 Monitoring of Effectiveness of Project Implementation

The KaR Project will adopt the use of a Water Poverty Index (WPI) as a tool to better manage the social and physical heterogeneity encountered in the Pesqueira/Belo Jardim region. The use of a WPI is consistent with more interdisciplinary approaches to water development initiatives throughout the world (Sullivan, 2002). A possible methodology for the elaboration of a WPI is included in Sullivan *et al*., 2003). The WPI approach described in Sullivan *et al*. (2003) combines information of physical and social characteristics of communities within a sustainable livelihoods framework increasingly used in development projects.

The adoption of a WPI in the KaR Project would result in a:

- Better understanding of social and physical heterogeneity in the region;
- The formulation of more effective policies;
- Better monitoring of Project impacts in regards to water use and management; and,
- Framework to discuss and plan future actions by Project participants.

The methodology will be complemented with other, qualitative, monitoring techniques.

Appendix A: Log Frame

	Narrative summary	Measurable indicators	Means of verification (MoVs)	Important assumptions
Goal	Reduce poverty in water scarce, semi-arid areas through sustainable use of groundwater resources, leading to a reduction in resource degradation and security in food production for the rural poor.	Uptake of guidelines by the water users should reflect in changing management and utilisation of the groundwater resource.	Feedback from post-project monitoring to be undertaken by the local collaborators.	
Purpose	Building the capacity of f local communities in semi-arid areas to achieve the sustainable use of groundwater resources for agricultural production and domestic needs. Long-term sustainable use of the groundwater resource, through local management of the resource by the end-users, will lead to: 1. Improved social standing in the local community (empowerment and participation in the management process) 2. Reduced vulnerability and more better livelihood outcomes through more secure food production (particularly during severe drought periods) 3. Reduction of harmful environmental impacts of over-exploitation of the groundwater resource (soil and water salinisation and stress on natural vegetation imposed by groundwater level decline)	1. Established groups of participants in the three trial areas. 2. Agricultural production in trial areas 3. Salinity patterns over the trial areas. 4. Water consumption in the trial areas. 5. Uptake and implementation of guidelines in farming communities across the wider region. 6. Greater water security for domestic purposes. 7. Interest in the results of the research by potential beneficiaries from areas outside of the pilot areas	1. Documented records of communications between the user groups and the working teams. 2. Enquiries from other regional bodies. 3. Reports 4. Published papers and web site	

Outputs	1. Clear understanding of livelihood framework for small farmers in the study areas (men and women), and the role of irrigation water in this 2. Guidelines for sustainable resource management for irrigation schemes at farmer level. 3. A Framework for farmer participation and education. 4. An operational strategy for integrated communications between farmers, researchers, managers and extension workers. 5. Guidance on convenient and cost-effective data collection strategies, involving individual farmers and farmer groups for the assessment of irrigation performance, water conservation and salinity control.	1. Publicity materials for farm level distribution. 2. Participation of farmers in monitoring. 3. Participation of local leaders in promoting the research activities and outcomes. 4. Acceptance and implementation of guidelines by the beneficiaries. 5. In-country open meetings and workshops to reach the local farming community (potentially co-ordinated through local radio). 6. Project reports and guidance documents. 7. Contributions to international meetings, publications in scientific and engineering literature and dedicated web site for international distribution	1. Produced materials including farm level monitoring records, meeting records and attendance, publications and web-based materials. 2. Reports	(Output to Purpose) 1. Beneficiaries engage in the communication process, with strong support from local leaders/institutions, NGOs and local/state government. 2. Active engagement of the beneficiaries in the implementation of the guidelines and in monitoring of responses to water management. The success of this engagement requires continuous monitoring and regular consultation. 3. Willingness of all parties to work together to achieve the project purpose. Good communication between the parties and adequate understanding of sustainable water management issues need to be ensured. 4. Sufficient data exist already to support the assessment of resource reliability and responsiveness to farmer practices. 5. The successful engagement of local beneficiaries in monitoring of the resource will depend on appropriate knowledge transfer and ability of beneficiaries to undertake the monitoring tasks.

Activities	1.a. Review current monitoring arrangements and implement new monitoring systems and schedules 1.b. Assess groundwater resource availability in each trial area and determine indicators of groundwater stress 1.c. Evaluate the impacts of groundwater development and the sustainability of the resource under different operational conditions and the timing requirements for intervention. 1.d. Disseminate the findings arising from 1a-1c through the communication channels created to address output 3 and the resources developed under activity 2. 2.a. Consult with end users, target audience representatives and local community leaders and establish the ground rules for interaction. 2.b. Perform socio-economic assessments aimed at identifying under-represented groups/genders concerned with the project goal and establishing the basis for their integration into the communication dialogue 2.c Carry out participatory livelihood analyses with small farmers (men and women) 2.d. Establish workshops, seminars and participatory surveys using the knowledge gained in 2.a. and 2.b. 2.e. Recording, reporting and evaluation of the results of the workshops and seminars. 3.a. Development of communication strategies aimed at producing effective multi-channel communication from the farm level through to national level encompassing farmers, water user communities, appropriate NGO's, public bodies, extension services and research organisations.	1.a. Integrated data base on existing and required monitoring points. Installation records for new monitoring points, and ongoing records from them. 1.b. Briefing reports provided through the project workshops. 1.c. As for 1.b. 1.d. Published materials produced by the project teams. 2.a. Records of meetings between work teams and users. 2.b. Working reports on the socio-economic assessments. 2.d. Flyers for workshops, participation lists and workshop reports. 2.d. As per 1.d. 3.a. Prepared reports on the approach to and development of the strategies.	(Activity to Output) 1.a. Adequate access to existing monitoring records and sites. 1.b/c Data can be collated on the alternative irrigation strategies under consideration by the farmers and the socio-economic basis for the implementation of these strategies. 2.a. Current good communications between the project team and the local community facilitate the consultation process. 2.b. Suitable representatives of under-represented groups can be identified. 3.a. Identification and engagement of appropriate level interactions with all representative groups in formulating the communication processes.

	3.b. Implementation of the communication strategy to contribute to and present the outputs of the technical research findings. 3.c Recording and reporting of the findings of this phase of the research.	3.b. Records of communications between represented groups. 3.c Output reports.	3.a/b. This assumes the adequacy of knowledge transfer and knowledge management at al levels. It also assumes that there is the willingness of all parties involved to actively participate in this process.
	4.a. Assessment of local capability to undertake resource monitoring and to interpret/disseminate the results 4.b. Development of guidelines and procedures for acquiring resource status data, processing the data and interpreting and distributing the results. 4.c. Development of resource stress indicators and the presentation of the basis for these and their dependence on future conditions. 4.d. Distribution of the guidelines and procedures and publication of the process.	4.a. Database of community representatives met and education/training needs assessments for those willing to participate in the research. 4.b Manuals and other information sources generated describing the techniques adopted for the assessment. 4.c Final report of the groundwater resource evaluation and monitoring studies. 4.d Final production of the guidelines.	4.a. The willingness of the local farm and water user communities to carry out the additional tasks required by monitoring and to acknowledge the need for such monitoring. 4.b. Sufficient resources are available to maintain the equipment base and the training requirements needed to introduce the local participants to the proposed methods. 4.c. Adequate information can be gathered through the project to assess the hydrological and water management interactions in a sufficiently robust manner for implementation by the farmers. 4.a-c. There will always be the risk that the assessment of sustainable resource availability will results in under or overestimates. It will be necessary to monitor the impacts of resource utilisation after completion of the research. Regular re-evaluations of resource availability can then be undertaken. The University of Pernambuco will be in a position to undertake this further work and we will seek potential sources of funding during the project.
			A.i Pre-conditions

Appendix B: PhD Proposal of Sami Hotimsky

Proposal for participating in the Project: "Sustainable use of groundwater in the semi-arid ribbon valleys of Northeast Brazil as a collaborator

The research project will study the processes that shape and alter the potential of resource-based communities to adapt to environmental and human-induced forms of stress. Adaptation processes are subject to the interdependencies of agents, the institutions in which they reside and with the resource base on which they depend. The building of adaptive capacity in the context of increasing climatic variability (caused by the ENSO phenomenon and climate change) becomes of central importance to reduce the condition of environmental criticality and social vulnerability found at the semi-arid region of Northeast Brazil.

The project will evaluate the opportunity for co-management of groundwater resources by increasing the adaptive capacity of local user groups and institutions in the region within the overall research program entitled: "Sustainable management of groundwater resources at a highly critical environment: the semi-arid ribbon valleys of Northeast Brazil.

The following research questions will be assessed:

(a) What are the processes that shape the adaptive capacity of resource-dependent communities to cope with environmental and human-induced change?

(b) What are the processes that affect the ability of societies and institutions to develop ecological knowledge to deal with environmental change and, in turn, how can they act to influence change?

(c) Is it possible to design cross-scale institutional linkages in a way that facilitates self-organisation in cycles of change, enhances learning, and therefore increases the resilience of social and environmental systems?

Thus the project will emphasize the role that social learning of ecological knowledge and its effective communication across different scales play in shaping adaptive capacity at the community level towards environmental change. The correct 'reading' of environmental signals may influence the ability of local water users to monitor and manage resources in a sustainable manner.

Appendix C: Socio-economic Survey

C.1 Introduction

The questionnaire included nine survey forms covering the following main topics:

1. General information about the respondent
2. Family details
3. Work
4. Health
5. Water sources
6. Drinking water for households
7. Household water (not including drinking water)
8. Drinking water for livestock
9. Irrigation

The forms are shown in the following pages.

The interpretation of survey results related to water is discussed in Section B.2.

Perfil do Público Alvo

Informações Básicas

N.º do questionário | Página 1

Data | Hora de inicio do questionário

Entrevistador

Comunidade | Hora da conclusão do questionário

1 Identificação

1.1 Nome:

1.2 Idade:

1.3 Sexo: 1.3.1 Masculino | 1.3.2 Feminino

1.4 N.º de pessoas na familia
- 1.4.1 Homens
- 1.4.2 Mulheres

1.5 Há quanto tempo mora aqui?

1.6 Você é:
- 1.6.1 assentado
- 1.6.2 parceleiro
- 1.6.3 morador

1.7 Tem documento?
- 1.7.1 Sim
- 1.7.2 Não
- 1.7.3 Não respondeu

1.8 Quais?
- 1.7.1 Certidão de nascimento
- 1.7.2 Identitade
- 1.7.3 CFP
- 1.7.4 Cert. Casamento
- 1.7.5 Titulo de Eleitor
- 1.7.6 Reservista
- 1.7.7 Batistério
- 1.7.8 Carteira profissional

2 Grau de escolaridade

2.1 até que ano você estudou?
- 2.1.1 Alfabetização
- 2.1.2 1º ano
- 2.1.3 2º ano
- 2.1.4 3º ano
- 2.1.5 1º grau completo
- 2.1.6 2º grau incompleto
- 2.1.7 2º grau completo

2.2 você sabe ler? sim | não

2.2.1 assinar o nome sim | não

Perfil do público alvo
Detalhes sobre os domicílios

N.º do questionário | Página 2

Data

1 Organização Social (associação)

1.1 Tem associação na comunidade? sim | não

1.2 caso sim, que tipo de associação?
- 1.2.1 Associação dos Produtores Rurais
- 1.2.2 Associação de mulheres
- 1.2.3 Outra

1.3 Você é membro da Associação? sim | não

1.4 Caso sim, quanto você paga? R$

1.5 Você acha importante a Organização? Sim | não

1.5.1 Por quê?
- melhora a vida da comunidade
- traz benefícios para a família
- outros

2 Aposentadoria

2.1 Você é aposentado? 2.1.1 Sim 2.1.2 Não

2.2 Você tem alguma parente aposentado? 2.2.1 Sim 2.2.2 Não

2.4 Quanto a aposentadoria lhe ajuda?
- 2.4.1 em nada
- 2.4.2 um pouco
- 2.4.3 muito

2.3 Quem é aposentado na sua família?
- 2.3.1 eu
- 2.3.2 avô
- 2.3.3 avó
- 2.3.4 pai
- 2.3.5 mãe
- 2.3.6 tio
- 2.3.7 tia
- 2.3.8 ninguém

3 Empréstimo

3.1 Você já recebeu algum empréstimo ou ajuda a fundo perdido para investir na agricultura e pecuária? 3.1.1 Sim | 3.1.2 Não

3.2 Caso sim, de que tipo
- 3.2.1 Pronaf
- 3.2.2 INCRA
- 3.2.3 FUNTEPE
- 3.2.4 Banco do Nordeste
- 3.2.5 Outro — Descreva

3.3 Para quê?

3.4 Você teve problema para pagar? Sim | Não

3.5 Caso sim, que tipo

4 Migração

4.1 Você já migrou (saiu daqui para morar ou trabalhar em outro lugar? 4.1.1 Sim | 4.1.2 Não

4.2 Caso sim, por quê?
- 4.2.1 Seca
- 4.2.2 Situação difícil (pobreza)
- 4.2.3 falta de oportunidade no lugar de origem (aqui)
- 4.2.4 laços de parentesco
- 4.2.5 outra — Descreva

4.3 Você migrou sozinho ou com a família?
- 4.3.1 Sozinho
- 4.3.2 com a família

4.4 Se você já migrou, por que voltou?
- 4.4.1 Porque tinha terra aqui?
- 4.4.2 Por que choveu?
- 4.4.3 Porque estava desempregado
- 4.4.4 Por causa da minha família
- 4.4.5 Outro

Descreva

4.5 Para onde você migrou?
- 4.5.1 Cidade do Sudeste ou Sul (São Paulo, Rio, etc.)
- 4.5.2 Zona rural no sudeste ou no sul
- 4.5.3 Para a beira do rio São Francisco
- 4.5.4 Para uma cidade no Nordeste
- 4.5.5 outro (mesmo município)

4.6 Quantas vezes você migrou?
- 4.6.1 Uma vez
- 4.6.2 de duas a quatro vezes
- 4.6.3 Mais de quatro vezes

Perfil do público alvo

Trabalho

Detalhe sobre os domicílios

N.º do Questionário ____ Página **3**

Data ____

1 Informações Gerais

1.1 Você trabalha? 1.1.1 Sim ☐ 1.1.2 Não ☐

3 Que tipo de trabalho você faz

- 3.1 Trabalho na Agricultura para venda de produtos ☐
- 3.2 Trabalho na agricultura para a famîlia ☐
- 3.3 Trabalho remunerado ☐
- 3.4 Trabalho com renascença ☐
- 3.5 Outro ☐

Descreva ____

2 Quem trabalha em sua familia?

2.1 Pai	☐	2.6 Mãe e Filhos	☐
2.2 Mãe	☐	2.7 Pai, Mãe e Filhos	☐
2.3 Pai e Mãe	☐	2.8 Esposo	☐
2.4 Filhos	☐	2.9 Mulher	☐
2.5 Pai e Filhos	☐	2.10 Outros	☐ Descreva
2.6 irmã	☐		
2.7 irmão	☐		

2 Divisão de Trabalho por gênero na agricultura e pecuária executado pela família

Tipo de Trabalho	sim	não	Quem executa
2.1 Limpa a terra	2.1.1 ☐	2.1.2 ☐	☐ Homem ☐ Mulher
2.2 Ara a terra	2.2.1 ☐	2.2.2 ☐	☐ Homem ☐ Mulher
2.3 Palntio	2.3.1 ☐	2.3.2 ☐	☐ Homem ☐ Mulher
2.4 Colheita	2.4.1 ☐	2.4.2 ☐	☐ Homem ☐ Mulher
2.5 irrigação	2.5.1 ☐	2.5.2 ☐	☐ Homem ☐ Mulher
2.6 fertilização de solo	2.6.1 ☐	2.6.2 ☐	☐ Homem ☐ Mulher

3 Divisão de trabalho por gênero na agricultura e pecuária executado por terceiros

Tipo de Trabalho	sim	não	Quem executa
3.1 Limpa a terra	3.1.1 ☐	3.1.2 ☐	☐ Homem ☐ Mulher
3.2 Ara a terra	3.2.1 ☐	3.2.2 ☐	☐ Homem ☐ Mulher
3.3 Palntio	3.3.1 ☐	3.3.2 ☐	☐ Homem ☐ Mulher
3.4 Colheita	3.4.1 ☐	3.4.2 ☐	☐ Homem ☐ Mulher
3.5 irrigação	3.5.1 ☐	3.5.2 ☐	☐ Homem ☐ Mulher
3.6 fertilização de solo	3.6.1 ☐	3.6.2 ☐	☐ Homem ☐ Mulher

4 Quanto é pago? R$ ____

5 Renda

5.1 De onde vem a maior parte da renda da família?

	Durante ano de chuvoso	Durante ano de seca
5.1.1 Agricultura	☐	☐
5.1.2 Renascença	☐	☐
5.1.3 Aposentadoria	☐	☐
5.1.4 Aposentadoria	☐	
5.1.5 Outro	☐	☐
		☐

5.2 Você vende a produção agrícola e pecuária? 5.2.1 Sim ☐ 5.2.2 Não ☐

5.3 Aonde?

- 5.3.1 Pesqueira ☐
- 5.3.2 latravessador ☐
- 5.3.3 Mercado local ☐
- 5.3.4 Outro ☐

Descreva ____

5.4 Caso alguém faça renascença, quem vende?

- 5.4.1 só as mulheres ☐
- 5.4.2 só os homens ☐
- 5.4.3 ambos ☐

Perfil do Público Alvo

Informações sobre a saúde

N.º do questionário _____ Página 4

Data _____

1 Doenças

1.1 Alguém da sua família tem doença grave? 1.1.1 Sim ☐ 1.1.2 Não ☐

1.2 Caso sim, que tipo de doença?

- 1.2.1 Cólera ☐
- 1.2.2 Febre tifo ☐
- 1.2.3 Diarréia ☐
- 1.2.4 Pressão alta ☐
- 1.2.5 Verme ☐
- 1.2.6 Osteoporose ☐
- 1.2.7 Doenças dos rins ☐
- 1.2.8 Hepatite A ☐
- 1.2.9 Diabete ☐ Decreva _____
- 1.2.10 Cansaço (Ira) ☐
- 1.2.11 Hanseníase ☐
- 1.2.12 Outra ☐

2 Em períodos de seca que doênças ocorrem com mais freqüência

		Sim	Não
2.1	Diarréia	☐	☐
2.2	Dengue	☐	☐
2.3	Pressão alta	☐	☐
2.4	Cansaço (ira)	☐	☐
2.5	Outra	☐	☐

3 Mortalidade Infantil

3.1 Teve algum caso de aborto na sua família?

- ☐ Sim
- ☐ Não
- ☐ Não sabe

3.2 Teve algum caso de óbito de crianças recém nascida na sua família?

- ☐ Sim
- ☐ Não
- ☐ Não Sabe

4 Doença Idosos

4.1 Que tipo de doença os idosos da sua família costumam ter?

- ☐ Cardíaca
- ☐ Pressão alta
- ☐ Diabetes
- ☐ Outras

4.2 Quem?

- ☐ eu
- ☐ avô
- ☐ avó
- ☐ pai
- ☐ mãe

Perfil sobre as famílias

Informações sobre água

N.º do questionário | Página **5**

Data

	Sim	Não
1 Você sabe o que é Poço Amazonas?		
2 Você sabe o que Poço Tubular?		

3	**Que fonte de água você usa?**	**Indicar o uso**	**Você usa água dessa fonte?**							
		Não existe 0 *Usa 1* *Não usa 2*	**Água de beber**		**Água para o sonsumo da família**		**Água para animais**		**Água para a irrigação de Produtos agrícolas**	
			Sim	**Não**	**Si**	**Não**	**Sim**	**Não**	**Sim**	**Não**
	3.1 Poço (1 poço)									
	3.2 Poço (2 poços)									
	3.3 Poço (3 poços)									
	3.4 Poço tubular									
	3.5 Cisterna de Captação de água de chuva									
	3.6 Dessalinizador									
	3.7 açude (1)									
	3.8 açude (2)									
	3.9 água suja									
	3.10 cacimba									
	3.11 Outra									

2	**Proprietário da fonte**	**Você é dono da fonte?**				**É a fonte comunitária ou privada?**		**Você permite que outras pessoas usem a sua fonte?**		**Você cobra pela água utilizada por outros?**	
			Sim		**Não**	**Comunitária**	**Privada**	**Sim**	**Não**	**Sim**	**Não**
	2.1 Poço (1 poço)	2.1.1		2.1.2							
	2.2 Poço (2 poços)	2.2.1		2.2.2							
	2.3 poço (3 poços)	2.3.1		2.3.2							
	2.4 Poço tubular	2.4.1		2.4.2							
	2.5 Cisterna de Captação de água de chuva	2.5.1		2.5.2							
	2.6 Dessalinizador	2.6.1		2.6.2							
	2.7 açude (1)	2.7.1		2.7.2							
	2.8 açude (2)	2.8.1		2.8.2							
	2.9 água suja	2.9.1		2.9.2							
	2.10 cacimba	2.10.1		2.10.2							
	2.11 outra										

Perfil do Público Alvo

Água de beber para as famílias

N.º do Questionário | Página 6

Data

1 De onde vem a água de beber?	1.1 No período chuvoso	1.2 No período seco	1.3 Existem problemas? Sim	Não	1.4 Caso sim, diga o tipo de problema	1.5 Se o problema for outro, diga	1.6 Caso sim, quando o problema ocorre?
	1 Poço amazonas	Poço amazonas	Poço amazonas				
	2 poço tubular	poço tubular	poço tubular				
	3 Cisterna	Cisterna	Cisterna				
	Captação de água de chuva	Captação de água de chuva	Captação de água de chuva				
	4 Dessalinizador	Dessalinizador	Dessalinizador				
	5 Açude	Açude	Açude				
	6 Carro Pipa	Carro Pipa	Carro Pipa				
	7 cacimba	cacimba	cacimba				
	8 outo	outro	outro				

Tipo de problema
1 *falta água*
2 *água Salobra*
3 *água suja*
4 *água muita cara*
5 *quebrado*
6 *outro*
7 *nao sabe*

quando o problema ocorre?
1 *período chuvoso*
2 *período seco*
3 *durante a seca*
4 *durante seca severa*
5 *outro*
6 *não sabe*

1.7 O que é feito da água utilizada pela família?	
	Perde-se é reutilizada
1.7.1 De que forma?	lavar a casa
	banheiro
	regar planta
	outra

2 Quem vai buscar a água de beber?	2.1 período chuvoso	2.2 período seco
	2.1.2 Homem	2.1.2 Homem
	2.1.3 Ambos	2.2.3 Ambos
	2.1.4 Criança	2.2.4 Criança
	2.1.5 Todos	2.2.5 Todos

3 Quanto tempo é gasto para buscar água todos os dias?	
3.2 no período seco	
3.3 na seca	

Tempo (horas por dia)
1 *<1(menos* de 1hora)
2 *1-2 (de uma* a duas horas)
3 2-3 (de duas a três horas)
4 >3 (mais de três horas)
5 não sabe

4. Aonde você guarda a água de beber?	
4.2	cisterna
4.3	Barril
4.4	filtro
4.5	balde com tampa
4.6	bombona
4.7	outro

5 Como é feito o transporte da água de beber?	
	5.1 caminhando a pé
	5.2 jumento
	5.3 carro
	5.4 carro de boi
	5.5 carroça de jumento
	5.6 outro
	descreva

6 Quanto de água de beber sua família usa ao dia? (lata/por dia)	

7 Você paga pela água que bebe?	Fonte Sim	Não	Caso sim quanto paga (reais por ja
	7.1 Poço amazonas		
	7.2 poço tubular		
	7.3 Cisterna		
	7.4 Dessalinizador		
	7.5 açude		
	7.6 carro pipa		
	7.6 outro		

9 opinião para melhorar situação de água	
9.1 Para beber	
9.2 Consumo da família animais	
9.3 irrigação de Produtos agrícolas	
9.4 irri gação cultivo quintal	

10 Quando as fontes secam o que é feito com relação	
10.1	a água de beber
10.2	água consumo da família
10.3	água para anaimais
10.4	água para irrigação de produtos agrícolas
10.5	água para irrigação de produtos cultivados no quintal

Perfil do Público alvo

Água para o uso animal

n.º questionário _____ página 7

Date _____

1 Você tem animal?	sim	não
(se não tiver, passe para a página seguinte)		

2 Quantas cabeças?	Dá o número
2.1 gado	
2.2 bode	
2.3 ovelha	
2.4 porcos	
2.5 galinha	
2.6 jumento	
2.7 outo	

3 De onde vem a água para o consumo dos animais?	período chuvoso	período seco	Existe problemas? sim	não	caso sim que tipo?	se outro (6) problema descreva	caso sim, quando o problema ocorre
	3.1 poço amazonas	poço amazonas	poço amazonas				
	3.2 poço tubular	poço tubular	poço tubular				
	3.3 cisterna	cisterna	cisterna				
	3.4 açude	açude	açude				
	3.5 cacimba	cacimba	cacimba				
	3.6 rio	rio	rio				
	3.7 outro	outro					

Tipo de problema
1 falta d'água
2 salobra
3 água suja
4 água cara
5 fonte quebrada
6 outro

quando ocorre
1 periodo chuvoso
2 período seco
3 durante a seca
4 durante seca severa
5 outro

4 Quem vai buscar a água para os animais?	período chuvoso	período seco
	4.1 mulher	mulher
	4.2 homem	homem
	4.3 ambos	ambos
	4.4 criança	criança
	4.5 todos	todos

5 Quanto tempo é gasto para regar água por dia?	
1 período	
2 período seco	
3 durante a seca	

Tempo(horas por dia)
1 *<1*
2 *1-2*
3 *2-3*
4 *>3*

6 Como é feito o transporte da água para os animais	
1 caminhando a pé	
2 carroça de jumento	
3 carro pipa	
4 encanada	
5 outro	

Descreva _____

7 Quantas latas de água é usada por dia para os animais? _____

Tipo de problema com acesso
1 proprietário não permite
2 estrada ruim
3 muito longe
4 dificuldade de chegar

8 Você paga pela água usada pelos animais?	fonte de água sim	não	caso sim, quanto é pago por l
	8.1 poço amazonas		
	8.2 poço tubular		
	8.3 cisterna		
	8.4 açude		
	8.5 cacimba		
	8.6 outro		

9 Existe problema com o acesso a água para os animais?	sim	não	caso sim, descreva
9.1 poço amazonas			
9.2 poço tubular			
9.3 cisterna			
9.4 açude			
9.5 cacimba			
9.6 outro			

Perfil do público alvo

Irrigação

N.º do questionário _____ página **8**

Data: _____

1	Você tem cultura irrigada?	sim	não
	(se a resposta for não encerre)		

2	Qual o ?	
2.1 Ç	2.1.1 cenoura	
	2.1.2 repolho	
	2.1.3 tomate	
	2.1.4 feijão de corda	
	2.1.5 outra	

3	De onde vem a água usada para a irrigação?	para cultura	Existe problemas	sim	não	caso sim, que tipo de problema	caso outro(6) descreva o problema	caso sim, quando o problema ocorre?	Caso outro (5) quando o problema ocorre
		3.1 Poço amazonas	Poço amazonas						
		3.2 poço tubular	poço tubular						
		3.3 cisterna	cisterna						
		3.4 açude	açude						
		3.5 água reutilizada	água reutilizada						
		3.6 cacimba	cacimba						
		3.7 outro	outro						

tipo de problema
1 faltad'água
2 água salobra
3 água suja
4 muito cara
5 quebrado
6 outro

quando ocorre
1 período chuvoso
2 período seco
3 durante a seca
4 durante seca severa
5 outro

4	Quem faz o transporte da água para irrigação		
	4.1 mulher	mulher	
	4.2 homem	homem	
	4.3 ambos	ambos	
	4.4 criança	criança	
	4.5 todos	todos	

5	Existe problema de acesso à água para irrigação?	sim	não	caso existe, descreva o problema
	5.1 poço amazonas			
	5.2 poço tubular			
	5.3 cisterna			
	5.4 açude			
	5.5 cacimba			
	5.6 outro			

tipo de problema de acesso
1 propietário não permite
2 estrada ruim
3 muito longe
4 dificuldade de chegar

6	Você paga pela água usada na irrigação?	sim	não
	6.1 Poço amazonas		
	6.2 poço tubular		
	6.3 cisterna		
	6.4 açude		
	6.5 água reutilizada		
	6.6 cacimba		
	6.7 outro		

7	você paga pela energia utilizada na irrigação?	sim	não

7.1 caso sim, quanto você paga por mês?
- menos de R$50,00
- mais de R$50,00

C.2 Discussion of Survey Results Related to Water

C.2.1 Sources of Water

The sources of water for household consumption included mainly wells and water trucks. Other sources are of less significance. Rainwater harvesting is not widespread and was only reported in Campo Alegre and Mimoso. Cistern are used for water storage and the supply of water is normally from water trucks.

Wells, water holes (unlined pits dug to the groundwater table) and water trucks are the main sources of water for animal consumption.

Only the respondents from Rosário reported water use for irrigation and wells are the main source of water.

There is generally little difference in the reported sources of water supply between normal and drought periods. In Campo Alegre the use of wells for drinking water use reduces during drought periods and more reliance is on supply by water trucks.

Data indicates that in Campo Alegre the whole family engages in the collection of drinking water, whereas in Rosário women mostly engage in this activity. This presents an interesting finding in regards to the gender division of labour. Women are usually those responsible to collect drinking water, however, when there is a scarcity of water, they are helped by other members of the household. This is the case in the rainy season in Campo Alegre and for both Campo Alegre and Rosário during the dry season.

Men are responsible for fetching water for animals in all of the surveyed communities. This is the case particularly for the large animals. The data reflects the gender division of labour at the household level.

Irrigation takes place mostly in Rosário and men generally take responsibility.

In all surveyed communities it takes les than one hour to collect water. There is some increase in time during drought and severe drought periods, although this rarely exceeds two hours.

In all of the communities, there seem to be people with serious illnesses in the families. In Campo Alegre, there are more women with serious health problems than men and in Rosário that seems to be the opposite.

C.2.2 Health Issues

The most serious illnesses that were reported include high blood pressure, osteoporosis, kidney disorder and heart related diseases. There is a higher incidence of high blood pressure among the male population, while osteoporosis is more common amongst women. Heart related diseases are more common among men.

The most common illnesses during drought periods are diarrhoea, dengue, and high blood pressure. Those illnesses are all related to water and water use. In the case of diarrhoea, it is usually caused by consumption badly managed or contaminated water. Dengue is caused by a mosquito bite (*aegiptus aedes*) found in water. The symptoms of this illness are high fever and diarrhoea. High blood pressure could be associated with consumption of salty water. It is most common amongst the Rosário

population. It is, however, not yet known whether there is a higher salt content in the water available in Rosário than in Campo Alegre.

The figures on the following pages represent findings of parts of the livelihood survey in graphical form.

Appendix D: Workshops

D.1 Training Workshop in Rosário

Training workshops were held at the end of the Inception Phase in two of the study areas: Rosário an Campo Alegre. It was decided to limit the workshops to the two study areas where socio-economic surveys had been undertaken. From experience gained in those two areas a survey and subsequent workshop are planned for Mutuca after completion of the Inception Stage.

The first workshop took place in Rosário on 5 March 2004. There were 56 participants from the local community, including women, men, youngsters, the elderly, local school teachers as well as the local health agent. All community members were invited so that the workshop could count on the participation of a heterogeneous group.

The agenda for the day was the following:

09:30 Opening

10:00 Presentation of a Cordel (Ballad) about water use, education and irrigation specially commissioned for this Project, done by four young people from Rosário

10:30 Visit to Rosário to view irrigated fields and water monitoring equipment

12:30 Lunch

13:30 Dialogue with the community about indicators on the sources and uses of water, problems and solutions

11:30 Presentation of the Video: *Sementes do Sertao* (Seeds of Sertão) by producer Sarah Bailey

16:00 Evaluation of the day

17:00 Refreshments and closure

The opening session was led by Abelardo Montenegro, the coordinator of the Technical component of the Project. Municipal Government representatives were present through the participation of the Pesqueira mayor and the secretary of Agriculture. The President of the Rosário Association and other local political leaders were also present.

The main objective of the workshop was to discuss with community members the Project goal, purpose and outputs, and the importance of active community participation in the Project.

The objective of the field visit was for community members to be acquainted with irrigation and irrigation in action and other climate, salt and water monitoring installations. It was an important occasion for those who had not had the opportunity to receive an explanation about the water monitoring equipment to understand its use and relevance. The participants, the majority of whom were men, were actively involved and asked several questions. It is important to mention that despite the fact that Rosário has been benefiting from irrigation for several years, not all community dwellers benefit from it and neither did many know how it is monitored. This was particularly the case of the landless community dwellers, i.e. the *moradores*. After returning from the field, there was a discussion and evaluation of the field experience and the participants all rated it as very important.

The afternoon session emphasised the important link between the field experience and its technical component and the social aspects of community life and organisation. There was an open discussion facilitated by Adélia Branco, the local social development consultant, on the identification of indicators about the sources of water, the use of water, the problems and the solutions. All of the participants were actively engaged in the discussions. The list of the indicators identified is shown below:

Sources of water

- Tap
- Wells
  - Tube Well (*Poço)*
  - Dug Well *(Cacimbão)*
- River
- Dam
- Lake
- Cistern (rainwater harvesting)
- Cistern (water tanks filled by water trucks or other means).

Uses of water

- Drinking
- Bathing
- Washing
  - Dishes
  - Clothes
  - The house
  - The car etc.
- Cooking
- Crops
- Animals

Problems

- Electricity (high costs to pump water from the wells to irrigate)
- Supply of piped water (lack of that for community use)
- Supply of irrigation water
- Transport (lack of efficient transportation)
- Lack of care/commitment
- Quality
- Dependency

- Waste – the most waste is through irrigation
- Lack of a sewage system in the community
- Insufficient number of rainwater harvesting cisterns

Solutions

- Economics to prevent waste
- Use of drip irrigation and micro-sprinklers
- Piped water – collectively from the well (*poço*)
- Individual source of water
- For quality water:
    - Use treated water when possible
    - Use water from the cistern for human consumption
    - Cover wells (*poços*)
    - Avoid pollution (rubbish, agrochemicals)
    - Protect (water) from animals
    - For transport – the cart
    - Strengthen the Association and its role in regards to consciousness raising of community members

The discussion was very objective an enriched by the different levels of experience of community members in regards to irrigation. At some points the municipal government was severely criticised.

Following the identification of indicators, the video *Sementes do Sertão* was presented. The video featured the importance of education and social organisation and focused on the experience of a Rural School in the municipality of Ouricuri, found in the semi-arid portion of Pernambuco, west of Pesqueira, in the hinterlands or *Sertão* area. The workshop participants had a very positive response towards the video. A feedback on the points made by the participants on the video was given to the TE team members and after that an evaluation of the workshop was undertaken by the whole group. The evaluation was very positive and one of the farmers present took the opportunity to call for a meeting to discuss the local Association and to propose an election for a new Board of Directors. He emphasised the fact that they needed to strengthen their mobilisation and participation and that from the discussions held during the workshop it was clear that without a strong organisation there was no way the community would benefit from the Project and contribute to sustainability. That seemed to be one of the most important achievements of the workshop.

D.2 Training Workshop in Campo Alegre

The second workshop took place in Campo Alegre on 23 March 2004. It had 65 participants, including women, men, youngsters, the elderly, local school teachers as well as local health agents. Besides the fact that all community members were invited so that the workshop could count on the participation of a heterogeneous group from Campo Alegre, several individuals from Mutuca and Rosário also took part.

Besides the participation of local farmers, the training sessions also included participation of representatives of the Municipal Government, including the mayor and the Secretaries of Agriculture

and Education. The Municipal Government also provided logistical support such as, transportation and food.

The agenda for the day was finalised in a Project team meeting in Recife on 22 March Account was taken of experience acquired in the first training workshop in Rosário in early March. The opening session and field visit were co-ordinated by Abelardo Montenegro, the local Project co-ordinator, and the community dialogue and evaluation of the day were facilitated by Adelia Branco, the local social development consultant.

The agenda was the following:

09:30 Opening

10:00 Presentation of a Cordel (Ballad) about water use, education and irrigation specially commissioned for this Project by four young people from Rosário.

10:30 Dialogue with the community about indicators on the sources and uses of water, problems and solutions.

11:30 Presentation of Video: *Sementes do Sertao* (Seeds of Sertão) presented by producer Sarah Bailey

12:30 Lunch

13:30 Visit to Rosário to view irrigated fields and water monitoring equipment

16:00 Evaluation of the day

17:00 Refreshments and closure

The workshop opening was led by Abelardo Montenegro and with the participation of the Pesqueira mayor and municipal secretaries of Education and Agriculture, councillors as well as the President and former President of the Campo Alegre Association and other local political leaders. The Project was introduced by members of the team.

The main objective of the workshop was to discuss with community members the Project goal, purpose and outputs, and the importance of active community participation in the Project.

The following session emphasised the important link between the field experience and its technical component and the social aspects of community life and organisation. There was an open discussion facilitated by Adélia Branco, the local social development consultant, and Pat Stocker, the social development consultant based in the United Kingdom, on the identification of indicators about the sources of water, the use of water, the problems and the solutions. All of the participants were highly engaged in the discussion. The list of the indicators identified is given below:

Sources of water

- Reservoirs of various types: small dams and small reservoirs
- Groundwater from dug wells and tubewells
- Water truck *(carro pipa*)
- Lake, river and stream
- Cistern

- Dams, including underground dams
- The Pão de Açucar Dam (not drinking water)
- Stone tanks (caldeirões – tanques de pedras)
- Rainwater harvesting

Uses of water

"Água é vida" – water is life

"*Água dá trabalho para muitos…"* – water gives work for a lot of people

- Domestic uses:
  - Drinking
  - Cooking
  - Cleaning
  - Washing clothes
  - Washing
  - Watering plants (contrasted to agriculture)
- Agriculture – irrigation
- Animals (for drinking)
- Bees (for bee-hives)
- Health – the importance of treated water
- Construction of:
  - Dams
  - Houses
  - Brick-making
- Water storage
- River transport
- Hydroelectric energy
- Car radiators
- Fire services
- Swimming pool

Problems

- Sources:
  - Insufficient to accumulate water
  - Insufficient water for drinking
- Salty water

- Health – (at the time of the workshop there were 60 cases of diarrhoea in the settlements of Alto Boa Vista and Rua Preta probably caused by contaminated water, according to health agents).
- Lack of reservoirs
- Polluted water due to drainage (and other) problems
- Lack of water treatment
- Natural waste and human waste of water
- Lack of initiative

Solutions

- Discussion about Pão de Açucar dam and the Xukurú
  - Salty water
  - Xukurú leader (cacique) does not deny Campo Alegre water
  - Xukurú conflict does affect the water they receive from the dam. Some do not want to release water. We need an agreement with the Xukurú. We also need to clarify now who controls the water now and who used to control it. After the January rains, the control went to the Xukurú. But before, during the 4-5 year drought, all was fine.
  - Difficult access to this water
  - Someone questioned whether water from this dam (salty) is not going to cause problems for agriculture.
- Some families live far from sources of water and need cisterns.
- Each family needs a cistern for drinking water
- Water for irrigation could be managed collectively
- Water needs to be piped
- Water needs to be treated
- Need a new large dam for the Ipojuca for surface water
- The new water law (*Lei das Águas*) envisages the formation of water users associations for users of wells (açudes e poços) but not of water from dams. There was a mention of citizenship – rights and responsibilities.

As it can be seen, the identification of the indicators which took place was presented in greater depth than during the Rosário workshop and the main reason for that was the participation of people from different communities as they were exposed to distinct realities and experiences.

The afternoon session started with a visit to Rosário so that the participants could see irrigation in action and other climate, salt and water monitoring installations. This was very important as both Campo Alegre and Mutuca do not benefit from irrigation in the same way as Rosário does. The participants were very interested and demonstrated a high interest.

Evaluation of the Day

Positive comments from participants:

- The teaching was well done
- Learning was very good
- The exchange of experiences in the morning was good
- It will be useful for the community and the children
- There was plenty of notice given for the workshop

Other comments:

- Those who did not participate are not interested. There is a total of 85 families in Campo Alegre. (a comment on the degree of membership of the Association)
- Those who stayed to the end will pass on what they saw and learnt to others
- It is up to the community to put the lessons into practice – and on our unity
- All depends on people's will
- Some were unable to stay until the end. It would be better, in the future to meet on Sunday. This is the day the Association meets. (This point of view was supported by all the women and some men but one man disagreed).

Appendix E: Well Survey Forms

Well Water Use Investigations General

Well Identification

Sheet **1**

Name of Person undertaking the Survey

Well Number
Locality (Mimoso etc)

Date and Day of Survey
Start & end of questions:

Description of well

Was photo taken? Y / N

Water Level from reference point on rim of well on day of visit (m)

EC of Water Sample on day of visit

Position (Descriptive)

Position (Co-ordinates) *(Use the GPS to determine this).*

Respondent

Community Position/ Family ?

How long have you used water from this well

How many other people use water from the well? Men : Women: Children:

Where do these people live ?

How far afield do people come for water from this well? m or km

When was the well originally constructed?

What modifications have been made to the well over the years?

Has the well been deepened? Y / N

If so, how many times?
How much each time? m

What is the at rest water level in the well at the end of the wet season? m

What is the at rest water level in the well in the dry season? m

What is the water quality like? - Salinity (Good, Average, Poor, Terrible)

Has the water quality deteriorated over the years? Y / N

If yes, describe how this has affected the community and livelihoods:

Is the well used for :		How many people benefit?	Are there people refused access?
Irrigation?	Y / N		Y / N
Drinking water ?	Y / N		Y / N
Household water?	Y / N		Y / N
Livestock?	Y / N		Y / N
Other? Describe:			

Well Water Use Investigations Irrigation

Well Identification _____ Sheet **2**

If the well is used for irrigation? Y / N
If YES, then : -
History:
How many hectares did the well irrigate when originally constructed? _____ ha

Which fields were irrigated at that time? *To be shown on a sketch map of the area - link to air photo.*

Which fields have been irrigated over the years? *To be shown on a sketch map of the area - link to air photo.*

What were the crops grown in the fields in the past?

Present:
How many hectares are currently irrigated?
Which fields are currently irrigated?

	Field 1	Field 2	Field 3	Field 4	Field 5	Field 6
Approximate area of each irrigated field (ha)						
What crops are grwon in each of these fields?						
When was each crop planted?						
When will each crop be harvested?						
Where will the crops be sold?						

What pumping equipment is currently used?

Pump type and discharge capacity (head, discharge)
Motor type?
How old is each piece of equipment
Pump
Motor

When currently irrigating

What is the at rest water level in the well? _____ m
What is the depth of water in the well at rest? _____ m
How long do you pump before the well is dry? _____ minutes/hours
How many times a day do you pump? _____

How many days per week do you pump in the dry season? _____
What time of year do you start irrigation? _____
What time of year do you stop pumping? _____
Why do you stop irrigation at this time? _____

Well Water Use Investigations — Water Supply

Well Identification _____ Sheet **3**

How many families are served with water from the well? _____
How do people carry water from the well to their houses? _____
How far do people carry the water to the house? _____
Do people tap into the irrigation system for houshold water? _____ metres Maximum _____ metres Average
Who is responsible for carrying water to the house? Y / N Man Y / N Women
Y / N Girl Y / N Boy

What do the people use the water from the well for:

		Answers:		
Drinking water	_____		3	*All people*
Cooking	_____		2	*Most people*
Washing clothes	_____		1	*Some people*
Personal washing	_____		0	*Nobody*
Cleaning the house	_____			

If used for drinking water, do people boil the water first? _____

How many animals are provided with water from the well?

Animal type:	_____	Number of:	_____
Animal type:	_____	Number of:	_____
Animal type:	_____	Number of:	_____

In the houses supplied by the well, how many houses have a rainfall storage collection system
Some / All / None _____

Where houses have a rainfall collection system
Total number of houses with collection systems _____
Do most roofs collect from 1 side or two? _____
How many months does the water stored last? _____
Is the water generally treated before drinking?
Yes/ No / Sometimes _____

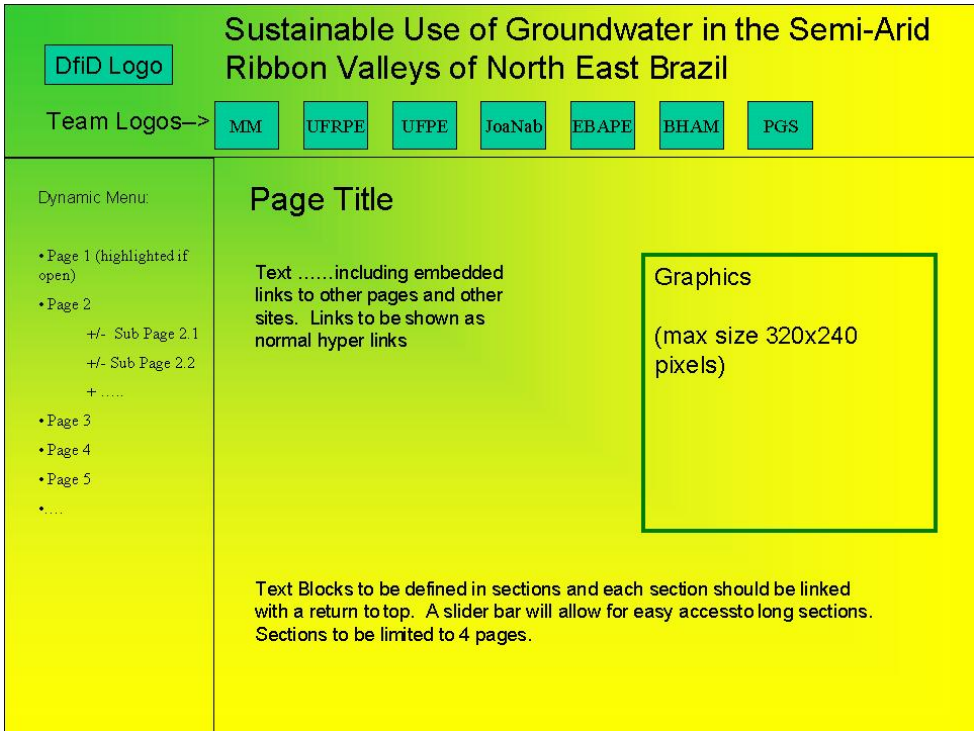
In the houses supplied by the well, are the houses also supplied by tanker delivery, or cart delivery

If yes: What is the additioanl source of water _____

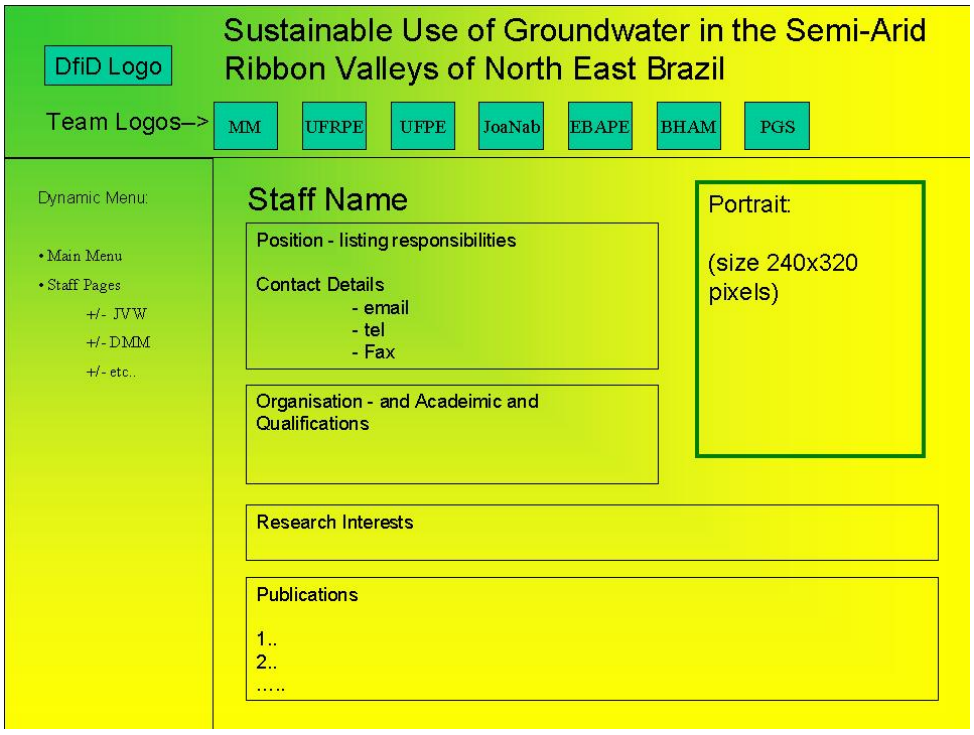
How many months each year do deliveries take place? _____
How many times a week are deliveries made? _____
How much do people pay for each delivery? Reis/ unit _____ m^3/barrel
What is the source of this water? _____ Distance? _____ km

Appendix F: Page Layout for Project Web Site

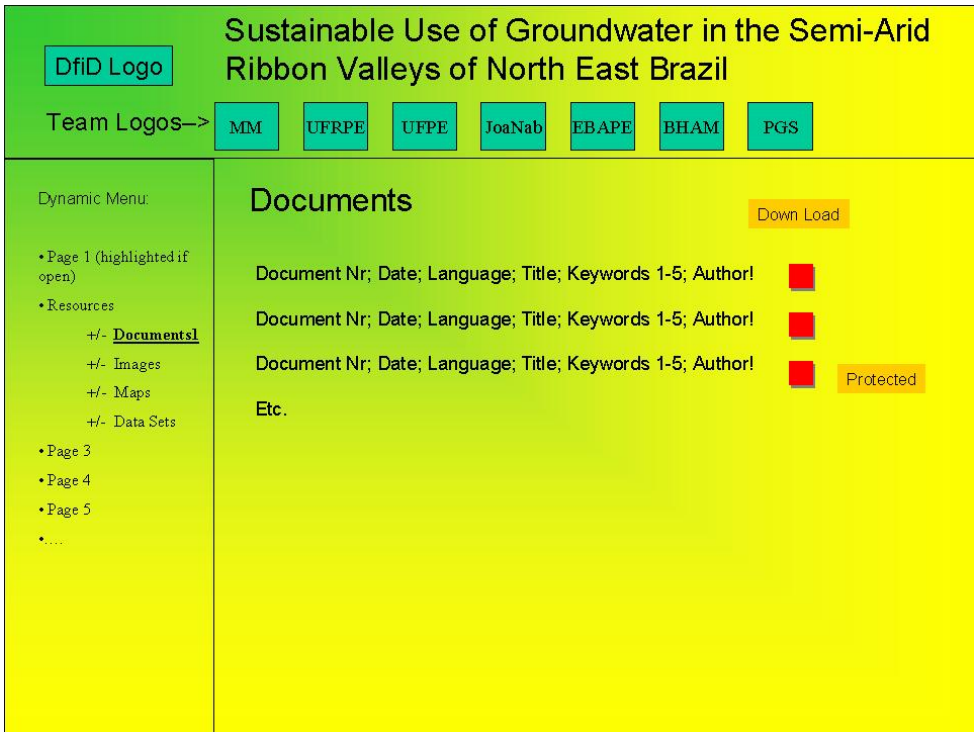
Standard Page



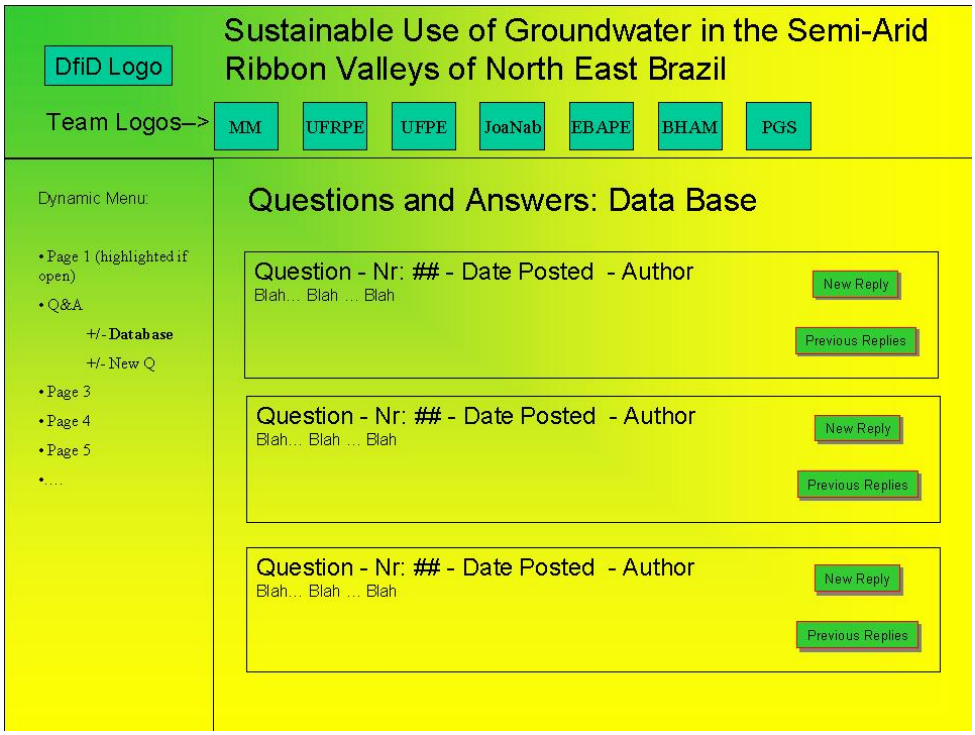
Staff Page



Documents



Q&A Database



Question Setting